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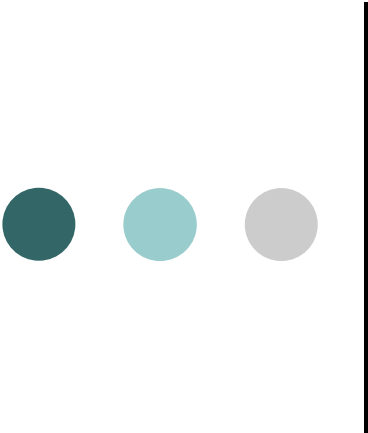
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# Community-Engaged Operations Research: Localized Interventions, Appropriate Methods, Social Impact

Michael P Johnson, Jr.



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# Community-engaged operations research: Localized interventions, appropriate methods, social impact

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## **Collaborators:**

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- Armagan Bayram (UMass Amherst '14), George Chichirau ('20), Rachel Drew ('14), Justin Hollander, Jeff Keisler, Gerald Midgley, Karen Smilowitz, Senay Solak, David Turcotte, co-authors

# Motivation

- High levels of social problems such as poverty, food insecurity, and housing costs
  - 46.7 million Americans in poverty in 2014<sup>1</sup>
  - 17.4 million were food insecure in 2014<sup>2</sup>
  - 39.6 million households with at least moderate housing burdens in 2013<sup>3</sup>
- Addressing these problems requires focus on
  - Underrepresented/isolated/vulnerable populations
  - Localized as well as national-level responses
  - Focus on recipients of social services and interventions as well as systems or physical infrastructure



<sup>1</sup> U.S. Census Bureau, Current Population Survey, 2015 Annual Social and Economic Supplement

<sup>2</sup> U.S. Department of Agriculture, based on Current Population Survey Food Security Supplement

<sup>3</sup> Joint Center for Housing Studies, Harvard University 2015

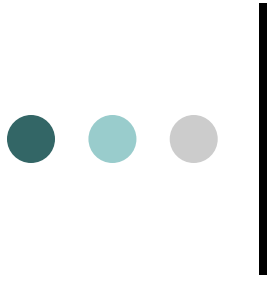


# Research questions

How can OR/MS provide theory, models and applications that can improve lives of individuals and communities?

Can solution approaches balance rigor and generality with specificity and impact?

Is OR/MS as commonly taught and practiced compatible with community change and social justice?



# INTRODUCTION TO COMMUNITY-ENGAGED OPERATIONS RESEARCH





# When can public-focused OR add value to society?

- When individuals or organizations seeking better ways to deliver goods or services define value in ways not limited to 'profit'
  - Reduction in food insecurity
  - Preservation of biodiversity
  - Maximization of property values
- When the goods or services delivered are not primarily traded in 'markets'
  - Public safety
  - Human security
  - Environmental quality
- When beneficiaries of goods and services provision lack political or social influence to set policy priorities
  - Racial and ethnic minorities
  - Low- and moderate-income individuals
  - Residents of socially- or geographically-isolated communities



# How can OR generate enhanced public impact?

- Multiple stakeholders
  - Client organization
  - Groups that experience externalities
  - Future generations
- Multiple objectives
  - Efficiency
  - Effectiveness
  - Equity
- Substantive engagement
  - Problem definition with, not just for, clients and stakeholders
  - Evidence that solutions can generate improved social outcomes, not only improved process measures





# Public-sector OR has had many successes...

- Design of policies for drug distribution to anticipate epidemic and pandemics
- Emergency management vehicle dispatch and scheduling
- Preservation of public safety against threats of terrorism
- Distribution of donated food to communities facing food insecurity
- Air transport management
- Hazardous materials distribution and storage
- Reserve management design

(and many others, see Pollock, Rothkopf and Barnett 1994, Larson and Odoni 2007, Kaplan 2008, 2016)



# But many important public are not as well-understood

- What measures of ‘resiliency’ are important to the well-being of vulnerable communities?
- How can low-income communities choose redevelopment strategies that balance opportunity and protection?
- How can economic development organizations identify performance metrics that balance local needs and capacity?
- How can a rural school district reconfigure its physical infrastructure and academic offerings to respond to declining enrollments and limited financial resources?

Problems that are hard to define, that require a deep understanding of local needs, and whose solutions depend on active community participation can be addressed using *community-engaged operations research*



# What are key characteristics of community-engaged OR?

- Emphasis on ‘intervention’ as opposed to observational science or quantitative methodological innovations
- Local engagement and impact
- Focus on disadvantaged and underserved populations
- Interest in problem-solving processes as well as outcomes
- Critical approach and concern for ethics
- Use of qualitative and mixed-method analytics (e.g. ‘soft OR’)
- Aim for community empowerment and social change

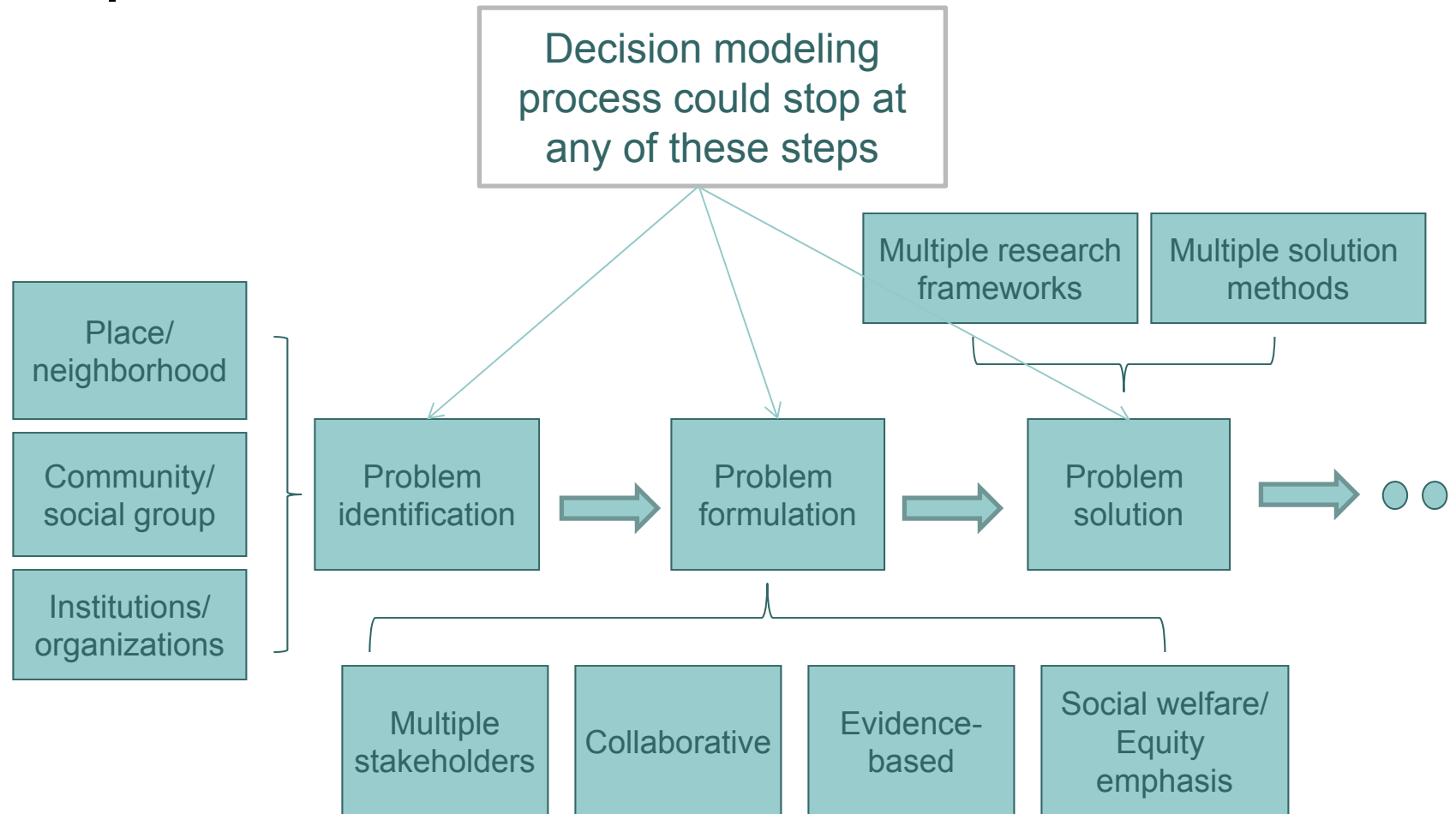
‘Community operational research’ (Midgley and Ochoa-Arias 2004) places greater emphasis on understanding and empowerment; ‘community-based operations research’ (Johnson 2012) places greater emphasis on analytic methods for policy, planning and operations prescriptions



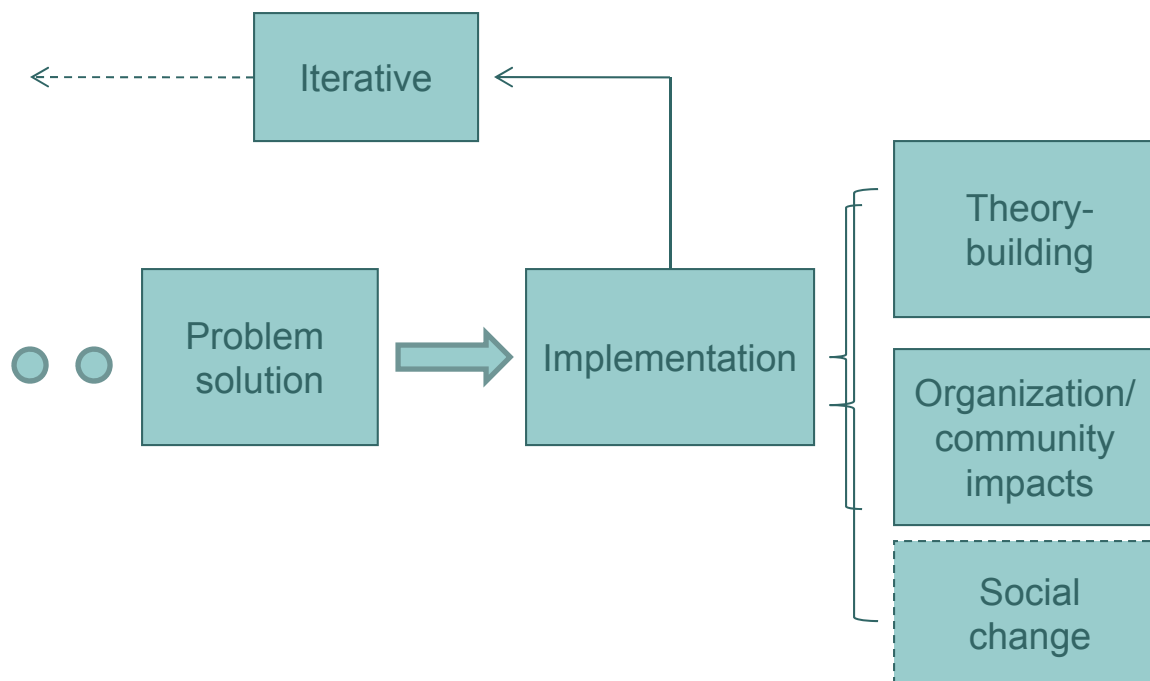
# What could a 'theory' of community-engaged OR be?

- Principles: Intervention, community engagement, critical perspective, social justice, community change, multi-methodology, mixed-methods
- Outcomes: Enhanced understanding of values, problem context and data; increased community capacity to formulate and solve problems; improved measures of individual and community well-being
- Questions:
  - Are individuals and communities better off after a COR/CBOR intervention? In what ways?
  - What are the benefits and costs of COR/CBOR approaches as compared to traditional OR/analytics approaches? Or other disciplinary solutions? For what communities and problem types?
  - What types of problems and community contexts are more promising for COR versus CBOR approaches?

# A process for Community-Based Operations Research



# CBOR process, continued

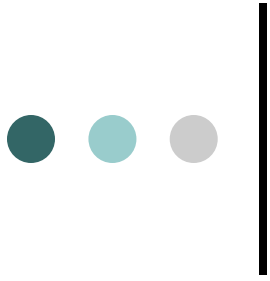




# What are challenges of community-engaged OR?

- Public-serving organizations and citizens may lack expertise for data-driven problem-solving
- Understanding problem context and identifying problem opportunities may be as (or more) important than model-building
- Community engagement is expensive, difficult and time-consuming
- Many problems are situated in social and political contexts that may be confusing, contentious or alienating

Community-engaged OR requires many skills not traditionally taught in many degree programs



# **EMERGING TRENDS AND NEW FRONTIERS IN COMMUNITY-ENGAGED OR**





# Emerging trends: Disaster planning



- Adaptation of logistics principles for planning for and responding to natural and man-made crises (Çelik et al. 2014)
- Usually concerned with systems-level understanding and quantitative modeling and solutions
- Community-engaged OR can integrate stakeholder experiences to address on-the-ground difficulties in disaster response (Munday 2015)

# Emerging trends: Analytics



- Composed of descriptive analytics, predictive analytics and prescriptive analytics (Liberatore and Luo 2010)
- Often seen as a 'superset' of OR
- Linked with explosion of data, business redesign and IT/Web innovations
- Community-engaged OR can emphasize qualitative data and methods, utility of data for individuals and communities, and role of communities in defining their own problems

# New frontiers: Urban planning and community development



- Goal is to make homes, neighborhoods and cities better places to live for all
- Available tools include land use management, community organizing, design of products and services to meet needs of urban neighborhoods (Hall and Tewdwr-Jones 2010; Levy 2017)
- Community-engaged OR can connect theory and methods of planning and development with decision science principles of problem identification, formulation and solution that emphasize process learning and stakeholder impact (Johnson et al. 2015)

# New frontiers: Information systems and information technology



- IS/IT is a well-studied field for design, development and evaluation of computerized tools and systems that crosses many disciplines
- However, IS/IT places less emphasis on community-engaged problem solving, and community-engaged OR has placed less emphasis on IS/IT for community interventions
- Participatory information systems, online community creation and engagement, localized applications addressing marginalized communities can be fruitful areas for community-engaged OR

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# New frontiers: Smart cities



- Common understanding emphasizes use of large datasets to improve operations and management of government and services through advanced technologies (Caragliu et al. 2009)
- Many applications reflect centralized, expert-driven tools and applications and centrality of surveillance state (White and Trump 2016), though recent work (Batty et al. 2012) acknowledge potential of 'citizen science'
- Community-engaged OR could influence design and implementation of smart city initiatives to reflect governance, digital divides and community concerns rather than technology and customer-facing applications



# New frontiers: Diversity and inclusion



- *Diversity* addresses recognition of differences, both valued and stigmatized, that affect individual and group social outcomes; *inclusion* reflects policies that enable organizations to better reflect community diversity
- Many D&I problems are amenable to quantitative, model-driven solutions (Shi 2015; Chen and Kesten 2016), but complex problems confront political and social barriers
- COR's strength in community engagement and critical approaches has resulted in multiple community-focused interventions (Cohen and Midgley 1994; Romm 2001), but more can be done to generate specific policies and prescriptions

# New frontiers: Indigenous people's issues



- 'First nations' populations struggle to achieve economic stability, cultural preservation and political empowerment in the face of cultural imperialism and exploitation by researchers (Smith 1999)
- COR has increasingly recognized issues of identity and indigenous problem-solving methods but struggled with conflicts between cultural norms (Midgley et al. 2007; Bishop 1996) that can inhibit Western-style research
- Community-engaged OR can deepen understanding of co-creation of problems and solutions and support development of culture-specific theories, methodologies and practices

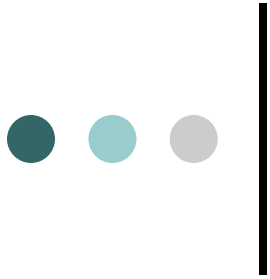




# Recent community-engaged OR projects

- Foreclosed housing development
  - What foreclosed properties should a community-based organization purchase to revitalize neighborhoods?
- Housing vacancies and municipal shrinkage
  - To what alternative uses can property currently or likely to be vacant be put to ensure municipal stability?
- EJOR special issue on community OR
  - What is the state of art in community-engaged OR? Can we increase the impact and disciplinary diversity of COR?

Common themes: Diverse solution approaches, evidence development, community engagement, multidisciplinary



# COMMUNITY-BASED POLICY AND PLANNING FOR FORECLOSURE RESPONSE





# Policy motivation

- Aggregate effects:
  - Over 4 million homes lost to foreclosure
  - 30% decline in house prices
  - \$7 trillion in home equity lost
- Socio-geographic concentrations:
  - High-priced areas that overbuilt
  - Economically struggling cities with high rates of subprime lending
  - Lower-income and minority households
- Social and economic consequences of foreclosures:
  - Residential stability
  - Personal well-being
  - Spill-over effects

(Sources: Joint Center for Housing Studies 2013; Immergluck 2010; McKernan et al. 2014)



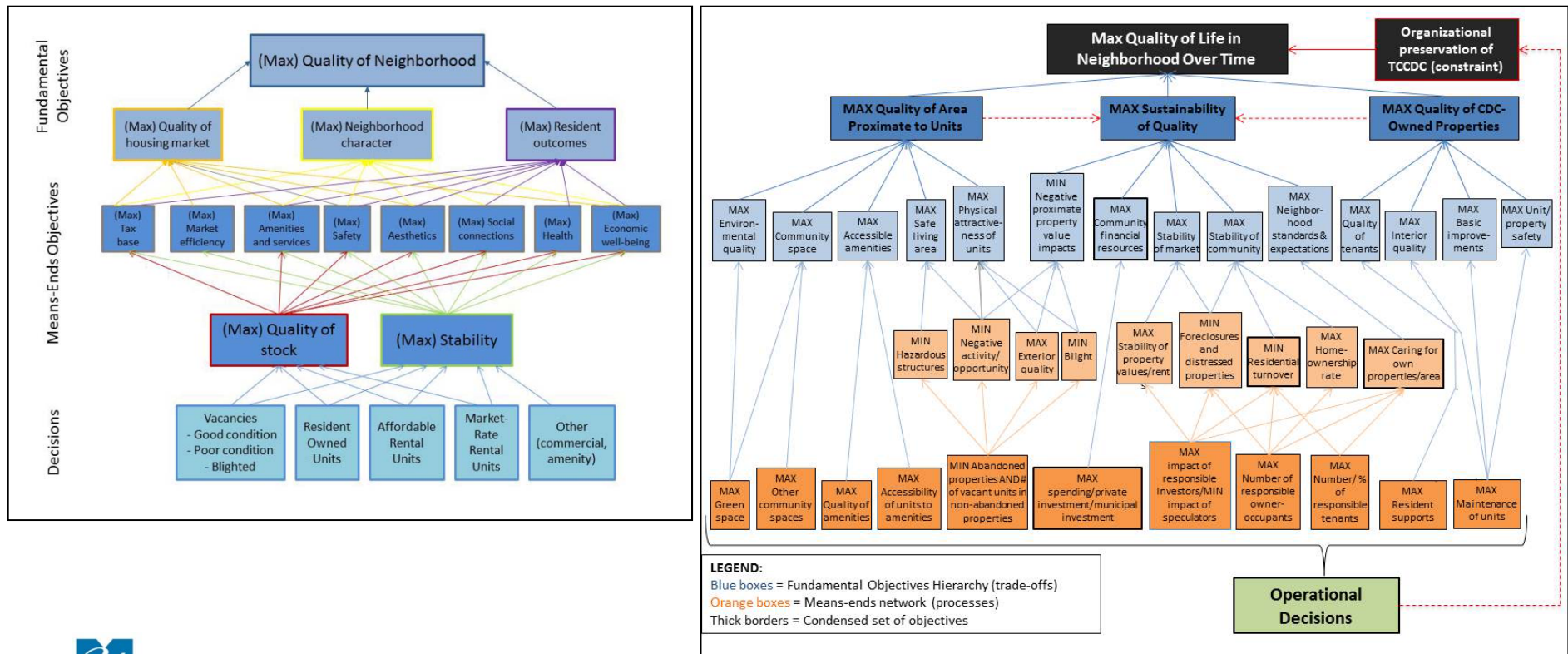
# Analytic response

- Focus on community-level foreclosure response: acquisition, management, rehabilitation, disposition of distressed properties
- Value-focused thinking: clarify objectives, attributes, decision opportunities
- Analytics: quantify impacts of foreclosure responses
- Stochastic dynamic programming: design bidding strategies and manage housing portfolios
- Multiobjective math optimization: identify acquisition and redevelopment opportunities



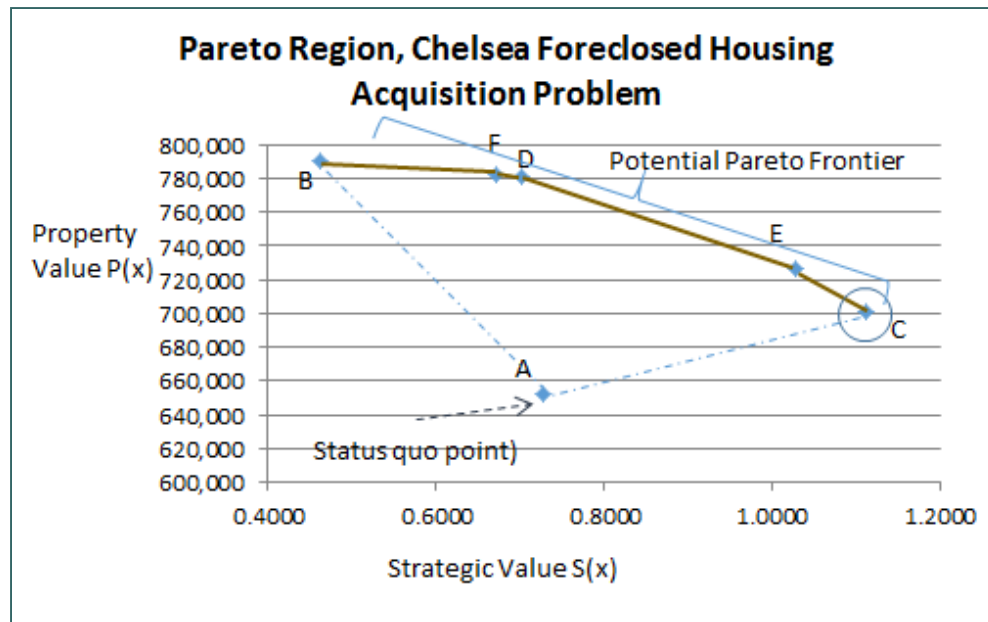
# Key findings: values analysis

Use value-focused thinking to identify decision strategies for diverse community partners



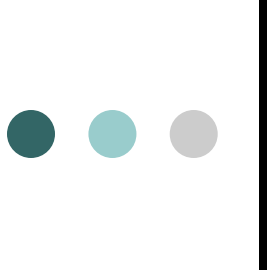
# Key findings: decision modeling

Use estimates of foreclosure response impacts to solve multiobjective optimization problem for property acquisition



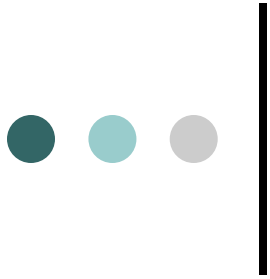
Candidate properties Model 1 corner solution 1:0





# Was this a successful application?

- Our goal was to use qualitative, community-engaged methods to identify solution opportunities, then solve empirical problems
- In practice, VFT applications yielded great insight, but quantitative analysis proceeded in parallel with qualitative analysis
- Funding limitations prevented solution implementation and community outcomes evaluation



# SHRINKING CITIES AND VACANT LAND MANAGEMENT







# Policy motivation

- Symptoms:
  - 30 cities with 500,000 or more residents have lost 8.61% of their populations on average
  - Number of vacant housing units has increased by 44%
  - Eight cities facing population declines have incurred \$23 billion in debt before declaring bankruptcy
- Causes:
  - Urban deindustrialization
  - Federal policy supporting out-migration to suburbs
  - Foreclosed housing crisis and the Great Recession
- Traditional remedies:
  - Investments in housing, employment and physical infrastructure

(Sources: Popper and Popper 2002, Hollander et al. 2009)

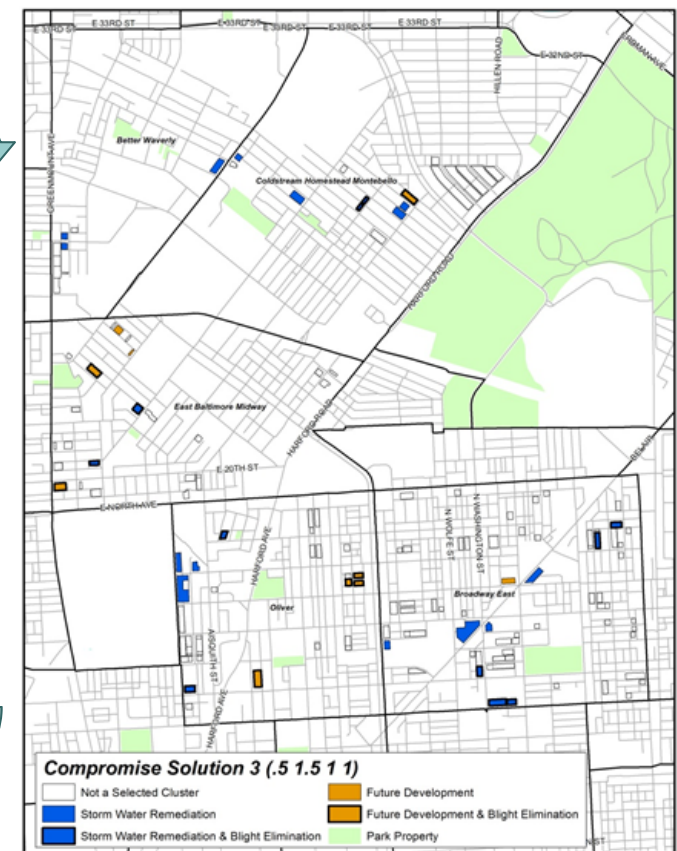
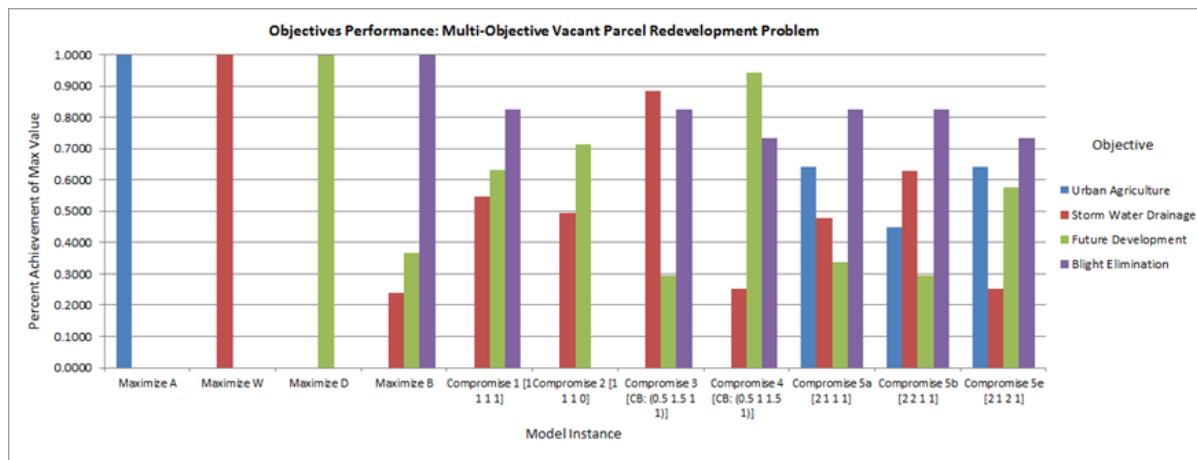


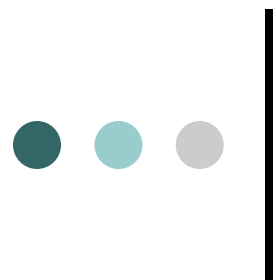
# Analytic response

- Classify vacant or abandoned parcels in blighted neighborhoods for multiple non-traditional uses
- Apply multi-objective optimization to select aggregations of parcels for new uses
- Evaluate actual decisions of planners for test data to infer values structures

# Key findings: prescriptive modeling

Multi-objective optimization: objective space vs. decision space

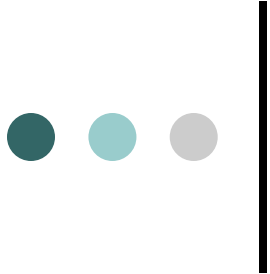




# Key findings: values analysis

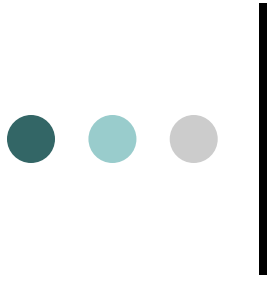
Values  
structures  
inferred from  
planner  
decisions using  
sample  
neighborhood  
data

Theme	Why Important	Criteria	Metrics
Strategic demolition and rehabilitation	Support existing homeowners and bolster redevelopment efforts	Blight elimination	Crime hotspots Code enforcement problem areas
		Support existing redevelopment	Proximity to areas with current redevelopment projects
	Improve quality of life for Baltimore residents	Whole block outcomes	Blocks with high vacancy concentration
		Neighborhood stability	Proximity to areas with high owner-occupancy
	Stabilize neighborhoods	Targeted investment	Proximity to areas with current redevelopment projects
			Proximity to areas with high owner occupancy
			Areas with high vacancy concentration
			Housing market typology (distressed categories)
Budgetary constraints and challenges	Apply limited funding in an equitable and maximally effective way	Equitable distribution of funds	
		Targeted investment	
		Cost	Minimal acquisition Minimal relocation Minimal need for structural supports
			Request from the community/community organizers/city councilmen, etc. Historic value/preservation



# Was this a successful application?

- Decision modeling approach meets needs of planners
- Researchers were prevented by partners from engaging with community stakeholders
- Social justice-focused ‘smart shrinkage’ is difficult to practice; brings baggage of previous discredited efforts such as urban renewal
- Current book project seeks to enlarge concept of data, technology and analytics to enable residents of distressed and declining communities to lead in local redevelopment



# **SPECIAL JOURNAL ISSUE ON COMMUNITY OPERATIONAL RESEARCH**





# Special issue description

Outlet: *European Journal of Operational Research*

Title: Community Operational Research: Innovations,  
Internationalization and Agenda-Setting Applications

Co-editors: Gerald Midgley, University of Hull; Michael  
Johnson, University of Massachusetts Boston

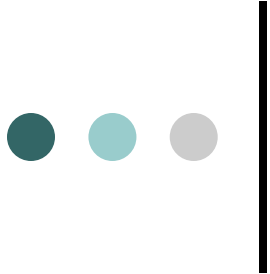
Call for papers: October 2015

Publication date: June 2018

Number of manuscripts: 31

In-press manuscripts available at:

<https://www.sciencedirect.com/journal/european-journal-of-operational-research/articles-in-press> →  
Search keyword “Community operational research”



# What is the special issue about?

- Motivation: Original focus of COR was OR serving community groups (grass-roots citizen movements); more recently communities wish to address highly complex social and environmental issues that require the involvement of public, private and voluntary sector organizations.
- Goals:
  - Highlight diversity of COR across application areas, geographies, methodological approaches and analytic methods
  - Demonstrate relevance of COR to ‘mainstream’ OR scholarship as well as more critical, multidisciplinary approaches





# Wide range of manuscripts

- Global geography: UK, US, South America, Asia, Africa
- Regional geography: Central cities, suburbs, rural areas
- Development context: Developed countries, developing countries
- Problem domains: Disaster recovery, community development/redevelopment, conflict resolution, human services, food security, education, social welfare, organization design, indigenous communities, community-focused enterprises



# Design of special issue

- Editorial
- (Re) Defining COR
- Theoretical and methodological contributions
- Prevention is better than cure: Working with youth
- Working with indigenous people
- Urban and community development and planning
- Rural development
- Interfaces with other practices and disciplines

# Contrasting approaches illustrate breadth of COR

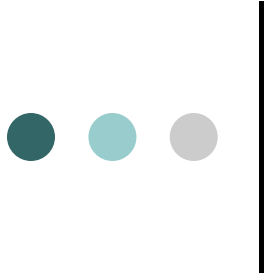
Title	Developing a business analytics methodology: A case study in the foodbank sector	Co-designing the solution space for rural regeneration in a new World Heritage site: A Choice Experiments approach	Teaching Decision-Making and Building Resilience in Youth: A Case Study to Reduce the Supply of Vulnerable Youth to Sex Traffickers in Atlanta, Georgia
Purpose	Develop a multidimensional view of business practice for social impact that maximizes value-added	Design and evaluate alternatives for the redevelopment of properties in the vineyard region of northern Italy	Engage vulnerable populations to improve their capacity for personal decision-making to better resist the temptations of sex work
Methods	Rich picture diagramming, business model mapping, activity model design, business model canvas, spatial data analysis	Facilitated modeling, stakeholders analysis, spatial SWOT analysis, choice-based conjoint analysis	Interactive planning problem structuring method, value-focused thinking; individual decision-making based on resilience framework
Findings	Business analytics is an emergent mix of top-down analysis and bottom-up action and can be practiced as a collective and community endeavor.	Experiment results provide guidance about solution strategies for specific parcels, and communicate to leaders the importance of capacity-building for localized planning expertise	Illustrates contrast between perceived and actual development of decision-making skills in youth and provides an empirical assessment of value-focused decision-making in a peer mentoring setting

Community engagement, mixed methods and capacity-building are central to the research goals of these papers



# What has the special issue taught us?

- Defining feature of COR: meaningful engagement of communities and concerned citizens.
- Methodological focus:
  - Qualitative methods rooted in systems science, soft OR, problem structuring methods, critical analysis, participatory action research
  - Mixed-methods and quantitative methods rooted in analytics and decision modeling
- The US/non-US conflict between methodological perspective is not as strong as one might assume
- Primary conceptual emphasis is on nature of engagement and theory-building rather than data and analytics



# Was this a successful application?

- There is potential for engagement between quantitative, prescriptive, 'US-style OR' and qualitative, critical, action research-oriented 'UK-style OR'
- Enormous benefits to cross-cultural, cross-disciplinary collaboration
- Greatest impact may be on scholars' conception of what OR can be, and community engagement in a challenging political environment

Is there a place for COR and CBOR in operations research, management science and analytics curricula?



# Conclusion

- Community-engaged OR is an emerging sub-discipline with ties to diverse research traditions and demonstrated organizational and social impacts
- Community OR and community-based OR can bridge gap between the success of 'hard-OR' in addressing well-defined and analytically complex quantitative problems, and the challenges of 'wicked' problems that require more inductive, collaborative and mixed-methods approaches
- Research rigor may come from theory-building and testing, novel methods of data gathering, support for impacts, creative development of appropriate decision technologies
- Promising community-engaged OR applications exist in diverse application areas within and outside of traditional OR domains



## Next steps

- Publish more COR/CBOR studies in traditional, prestigious OR/MS outlets...
- ...as well as scholarly outlets less-commonly used in OR/MS
  - Urban, community and regional planning
  - Policy and urban studies
  - Race, ethnicity and gender studies
- Deepen the theoretical understanding of COR/CBOR
  - Political economy of OR/MS
  - Increased use and justification of multi-methods



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