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Methods: Mind the Gap Webinar Series

Geospatial Data for Healthy Places: Building Environments for Active Living Through Opportunistic GIScience

Presented by

Harvey J. Miller, Ph.D.

The Ohio State University

THE OHIO STATE UNIVERSITY

Geospatial Data for Healthy Places:

Building Environments for Active Living through Opportunistic GIScience

Harvey J. Miller

Department of Geography &
Center for Urban and Regional Analysis
The Ohio State University
Columbus, Ohio USA
miller.81@osu.edu
@MobileHarv

NIH Office of Disease Prevention (ODP) Methods: Mind the Gap Webinar Series
19 September 2019

Introduction

Healthy places

- Encourage physical, mental and social well-being
- Facilitate physical activity and access to healthy food
- Minimizing exposure to risks such as poor air quality, heat stress and injuries
- Inclusive, legible and convivial environments that maximize social interaction

Introduction

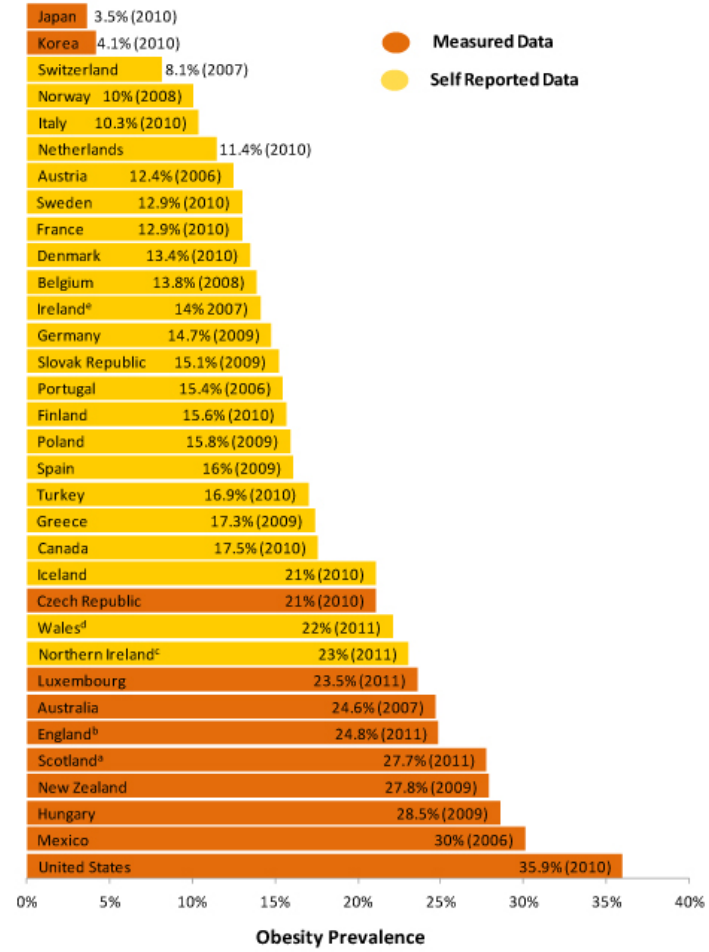
Many places are unhealthy!

- Discourage physical activity
  - Physical activity is unnecessary
  - And often unpleasant, unsafe, unhealthy
- Health consequences
  - Sedentary lifestyle diseases such as obesity, diabetes, heart disease, cancer
  - Leading risk factor for mortality in US
  - Fourth leading risk factor globally

http://www.newurbanism.org/

Introduction

Figure 1: Adult obesity prevalence, latest available data



Public Health England https://www.noo.org.uk

Introduction

Active living and healthy cities

- Integrate planning/design with evidence-based health policy
  - Planning and design interventions
  - Data collection and evaluation

- Science and policy initiatives
  - Healthy Cities
  - Active Living Research
  - Complete Streets
  - Active Design

ACTIVE LIVING RESEARCH
Promoting activity-friendly communities

Introduction

Problems

- Human systems are complex
- Policy interventions can have unclear and counterintuitive outcomes

Solutions

- Ecological approach
- Evidence-based policy

Strategies

- Opportunistic GIScience
- Geographic Information Observatories

Remainder of talk

Healthy environments

- Design interventions
- Ecological approach

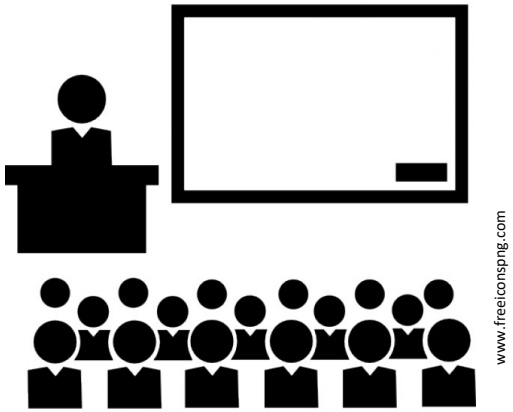
Real-world experiments

- Moving Across Places Study (MAPS)
- Does public transit generate *new* physical activity?

Opportunistic GIScience

- Geographic information observatories
- Leverage real world events

Conclusion



Healthy environments

Physical activity by design

Five D's of walkability

1. Diversity of activities
2. Density
3. Distance to public transit
4. Destination accessibility
5. Design

Complete Streets

Roads as habitats for all users, including pedestrians, cyclists and transit users

First Avenue Improvements, New York City

bikepgh.org

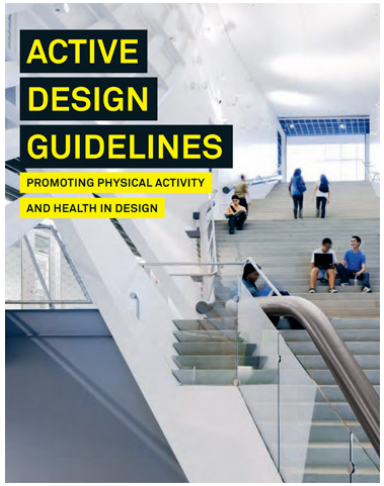
Complete Streets intervention in NYC

Healthy environments

Active design

- **Urban design strategies** that encourage walking, bicycling, and active transportation and recreation

- **Building design strategies** for promoting active living where we work and live and play, through the placement and design of stairs, elevators, and indoor and outdoor spaces



centerforactivedesign.org

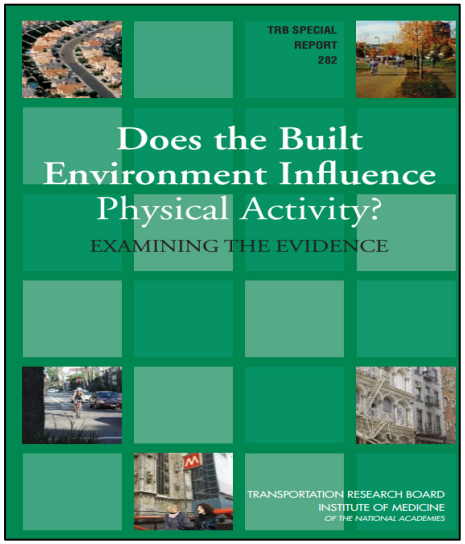
http://designlike.com/

Active design in Hangzhou

Unclear outcomes from design interventions

Rich people walk and bike for different reasons than poor people do

By Ben Adler on Jan 15, 2016



PHYS ED

Stand More at Work, Sit More at Home

By GRETCHEN REYNOLDS NOVEMBER 4, 2015 5:30 AM 36

Getty Images

Email Share Tweet

Using a standing desk at the office may adversely influence how much time you spend lounging in a chair at home, according to a new study of sedentary behavior. The findings subtly underscore that, when it comes to health habits and exercise, we humans have a surprising capacity to be our own worst enemies.

Sitting will kill you, even if you exercise

By Jen Christensen, CNN

Updated 8:40 AM ET, Thu April 30, 2015

Cities
Resilient cities

The sickness at the heart of modern cities is clear. But what's the cure?

The prevalence of lifestyle diseases such as type 2 diabetes is rising alarmingly in cities across the world. But the social factors driving this epidemic are complex and need our urgent attention, writes **Richard Florida**

Air pollution: should it stop you exercising?

Before the London Olympics, athletes were warned about the city's smog levels. And perhaps they're not the only ones who should worry ...

Should you wear a face mask when cycling in cities? Photograph: Ashley Cooper/Corbis

Today in Gender Gaps: Biking

By Amanda Marcotte

901

A woman and her bike.

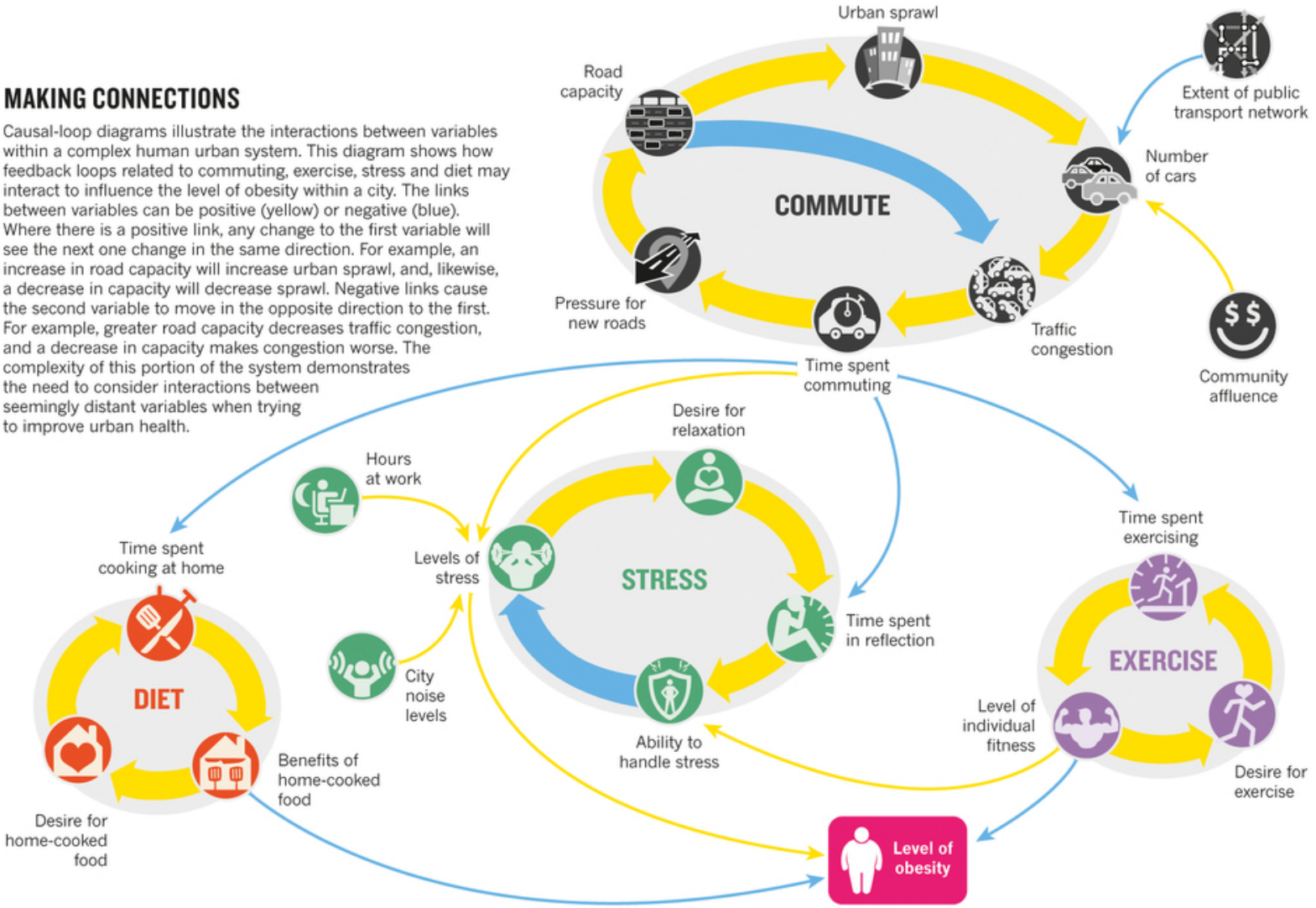
Photo by Oli Scarff/Getty Images

Healthy environments

Why unclear outcomes?

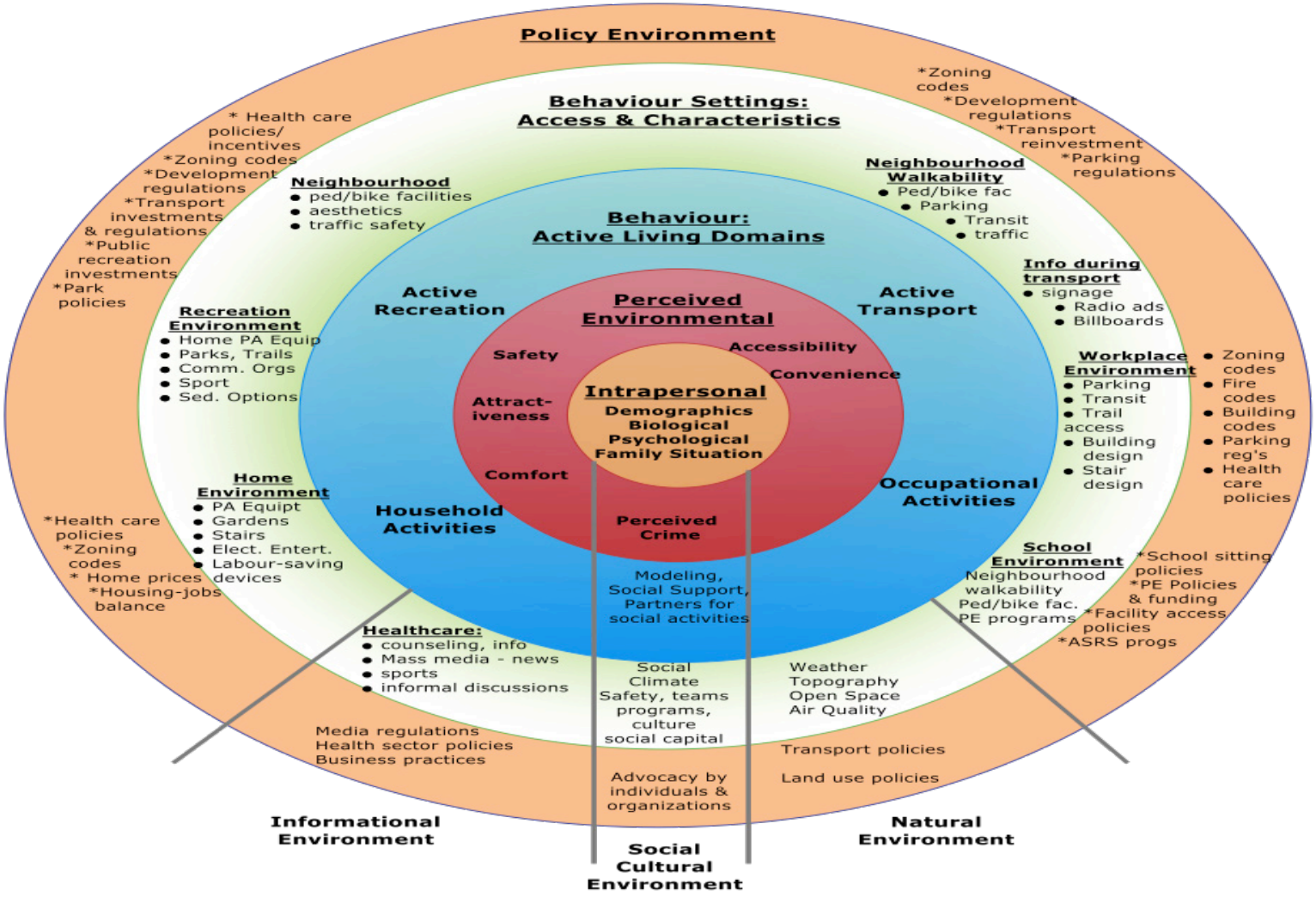
- Endogeneity: e.g., people self-select for walkable neighborhoods
- Context-dependence: e.g., walkability near home versus work
- Social factors: socioeconomic status, age, gender roles
- Compensation effects: e.g., standing at work leads sitting at home
- Unhealthy environments: e.g., air quality in urban canyons, heat stress, sick buildings

Cities and obesity – multiple layers of feedbacks



Pollock, K. (2016) *Nature*, 531, S64–S66 (17 March 2016)

Ecological approach to active living research



Sallis J.F. et al. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health,* 27 297-322.

Healthy environments

Ecological approach to healthy design

Multiple levels of influence

Personal characteristics, behavioral domains, settings and policy

Holistic

Transportation, recreation, work, household activities
All major facets of active living

Evidence-based

- Objective measures > Self-reports
- Longitudinal studies > Cross-sectional
- *Experiments: Gold standard for causality*

Real-world experiments

Treatment vs. control?

Lab: Random sorting

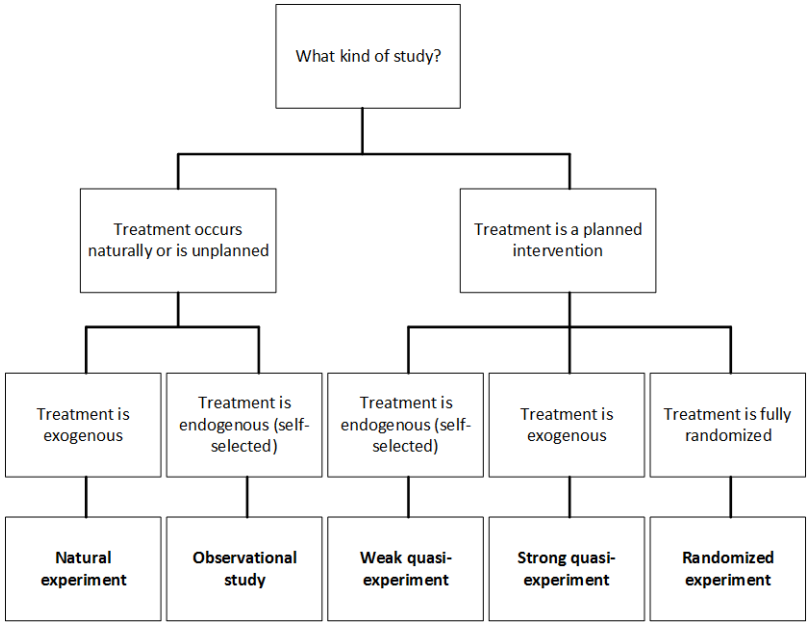
Real world: Infeasible, unethical

Quasi-experiments

Planned events or interventions in the real world

Natural experiments

Unplanned or natural events in the real world



Natural versus quasi-experiments

Remler D K and Van Ryzin GG (2015). *Research Methods in Practice: Strategies for Description and Causation*, second edition.

Real-world experiments

Moving Across Places Study (MAPS)

- Impacts of Light Rail Transit and Complete Streets on physical activity (PA)
- Salt Lake City, Utah, USA

A quasi-experiment

- Measurements of same participants before and after planned intervention
- Case (near) and control (far) groups


MAPS Overview
Airport Line Stops
Existing Stops
Airport TRAX Route
Existing TRAX Lines
Study Area
Near Group
0 500 1,000 2,000 Meters
Data: AGRC; ESRI; Author. 2012.
Salt Lake City Int'l Airport
Wingpointe Golf Course
West Point
Riverside Park
Constitution Park
Rosewood Park
Warm Springs
Sherwood Park
Pioneer Park
Popular Grove Park
9th South Park
Jordan Park
Jefferson Park
Salt Lake City
W North Temple
W Northtemple St
W South Temple St
W South Temple
Terminal Dr
N Redwood Rd
S Redwood Rd
Victory Rd
Beck St
Surplus Canal
Jordan River

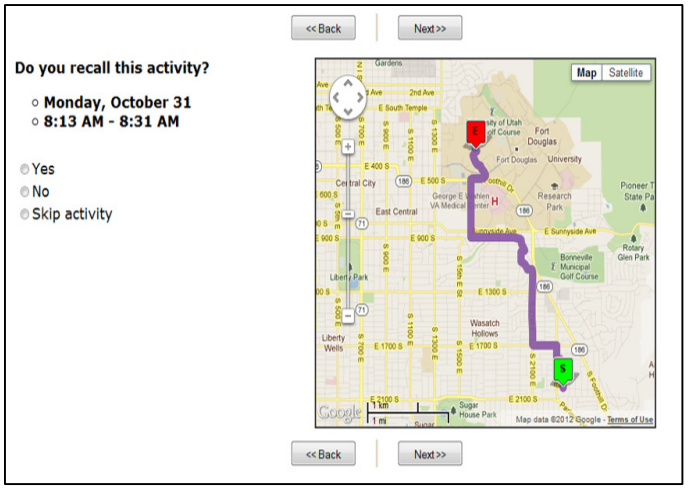
Real-world experiments

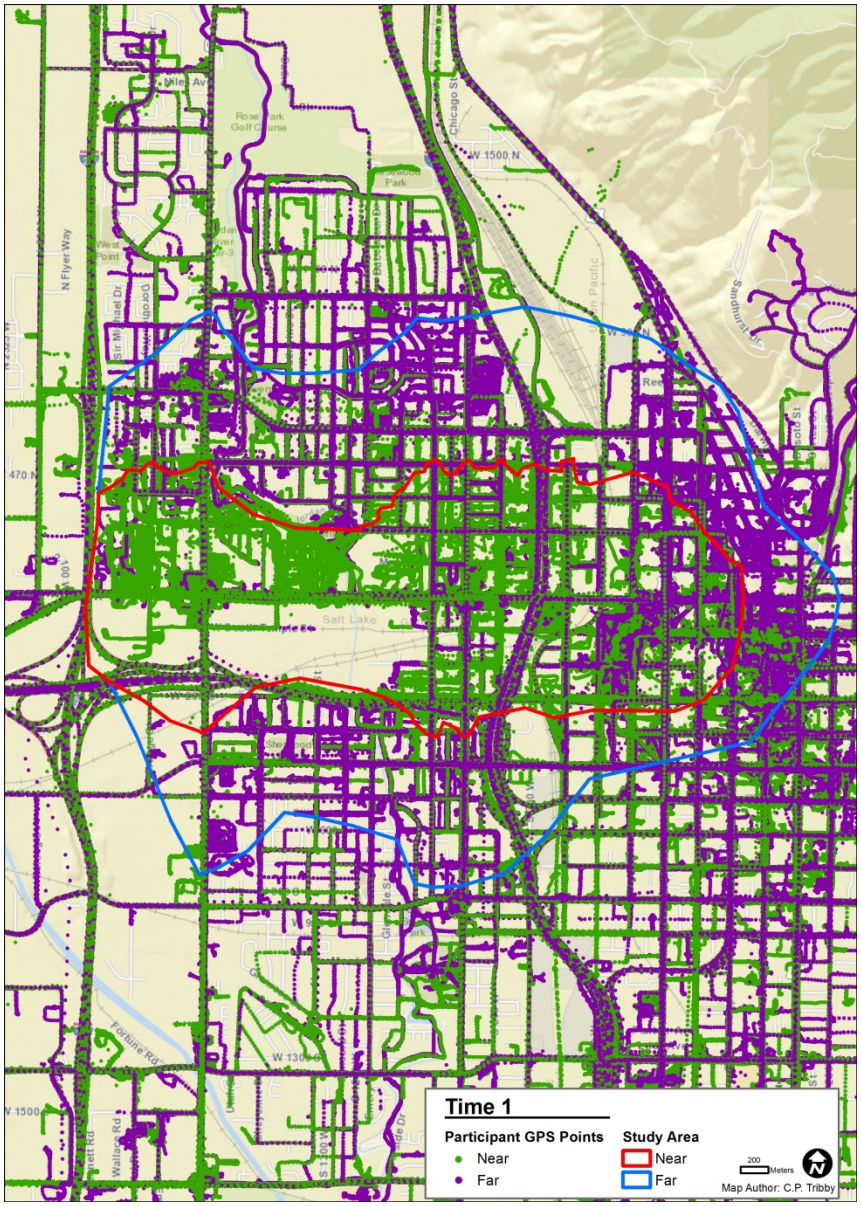
Data collection

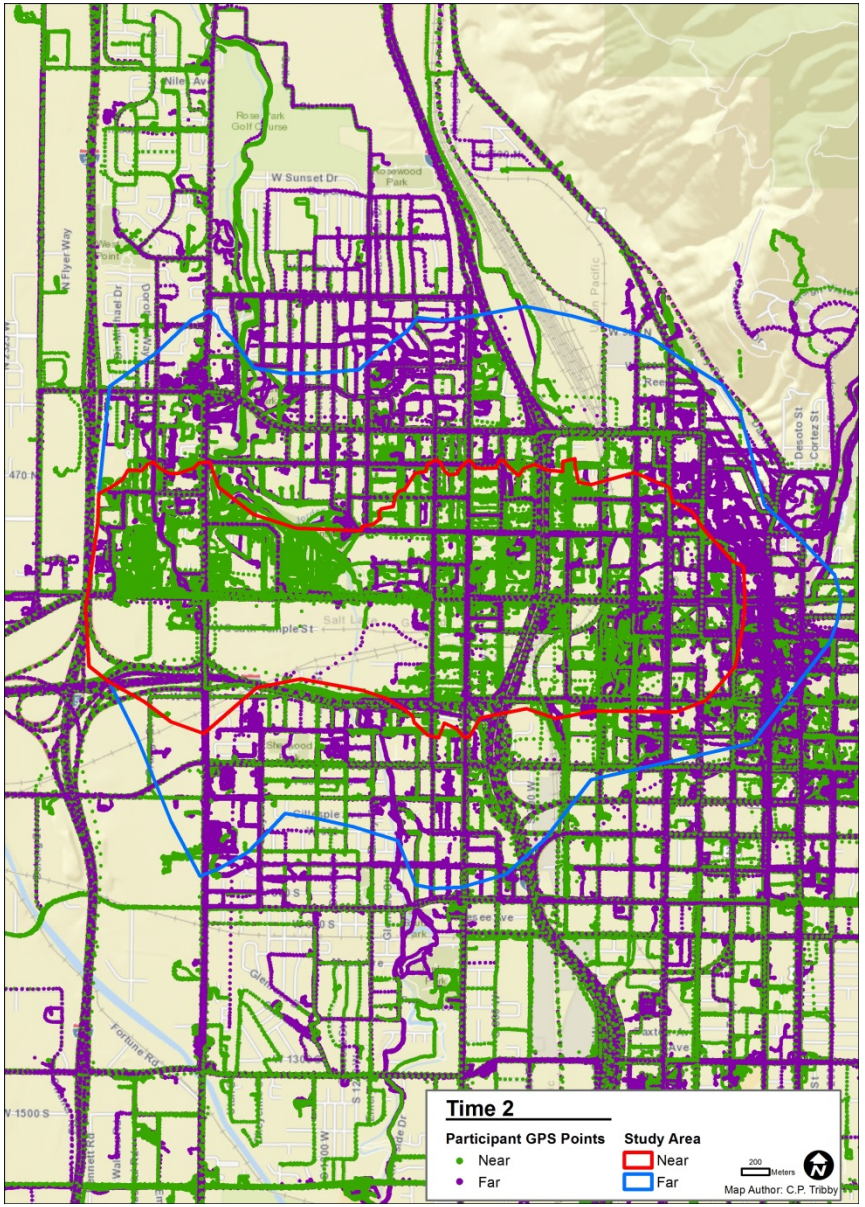
- Height, weight measurements; attitudinal surveys
- GPS + accelerometer wear for one week
- 2012 (before) and 2013 (after)
- Complete sample: n = 536

Data pre-processing (Westat)

- Uploaded, fused and map-matched
- Download for participant review
- Mode detection: Walk, bike, car, bus, LRT







Big geographic data? Approximately 4 million GPS points for each time period

Real-world experiments

Walkability audit

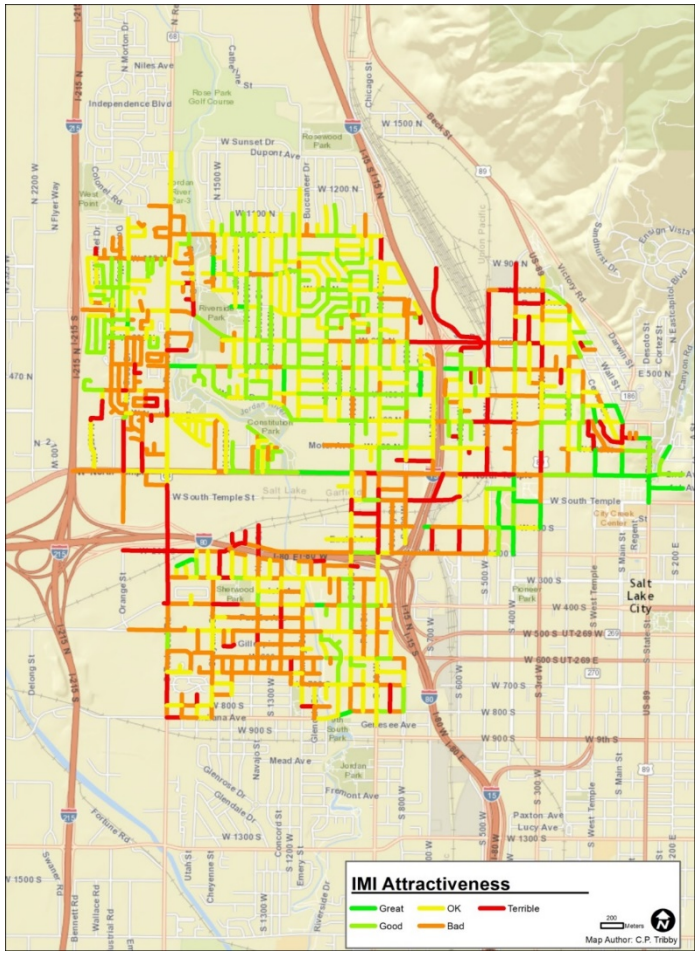
Irvine Minnesota Inventory (IMI)

160 attributes / 6 dimensions

1. Accessibility
2. Attractiveness
3. Traffic safety
4. Crime safety
5. Density
6. Pedestrian access

Block-level survey

1000+ block faces
2012 and 2013



Real-world experiments

Major project aims

1. Increases in transit riders, cyclists and pedestrians?
   Brown BB, Tharp D, Tribby CP, Smith KR, Miller HJ and Werner CM, *Journal of Transport & Health.*
2. Living proximal → larger activity increases? Brown BB, Smith KR, Tharp DS, Werner CM, Tribby CP and Miller HJ (in press) *Journal of Physical Activity & Health*.
3. Perceived walkability, pro-neighborhood → greater use?
   Brown BB, Werner CM, Smith KR, Tribby CP, and Miller HJ (2014) *Preventive Medicine*, 66, 140–144.
4. Complete Streets users → healthy PA + BMI changes?
   Brown BB, Werner CM, Tribby CP, Miller HJ and Smith KR (2015) *American Journal of Public Health.*

Real-world experiments

Other studies

Walking and built environment (Calvin Tribby)

- Walkability summary and visualization. Tribby CP, Miller HJ, Brown BB, Werner CM and Smith KR (2016) *Journal of Transport and Land Use,* 9, 1-21.
- Geographic regions for assessing walking trips. Tribby CP, Miller HJ, Brown BB, Smith KR and Werner CM. (2017) *Health and Place,* 45, 1-9.
- Walking route choice through built environments. Tribby CP, Miller HJ, Brown BB, Werner CM, and Smith KR (in press) *Environment and Planning B: Planning and Design.*

Public transit

- LRT did not cannibalize bus ridership. Werner CM, Brown BB, Tribby CP, Tharp D, Flick K, Miller HJ, Smith KR and Jensen W (2016) *Transport Policy*, 45, 5–23.
- **Does public transit generate *new* PA?**

Real-world experiments

Does public transit generate *new* PA?

We know transit users are more active
Self-reports, cross sectional analysis

But this may not be *new* PA
Undermines claimed health benefits

Why not new PA?

Confounding
Other, non-transit factors such as density, mix

Substitution
More time for transit → Less time for recreation

Real-world experiments

Physical activity bouts

Min 5 minute with a min of 1000 accelerometer counts per minute
(Saelens et al. 2014, *AJPH*, 854-859.)

Types of PA

Transit-related PA (PA-Transit): PA within a trip that contains bus or LRT

Non-transit PA (PA-Other): PA that does not occur within a trip with bus or LRT

Overall PA (PA-Total): PA-Transit + PA-Other

Real-world experiments

Public transit user

Participant who rode either bus or LRT at least once during data collection week

Transit groups (below)

Transit group	N	Public transit user in: 2012?	2013?
Never	391	No	No
Continued	51	Yes	Yes
Former	42	Yes	No
New	52	No	Yes

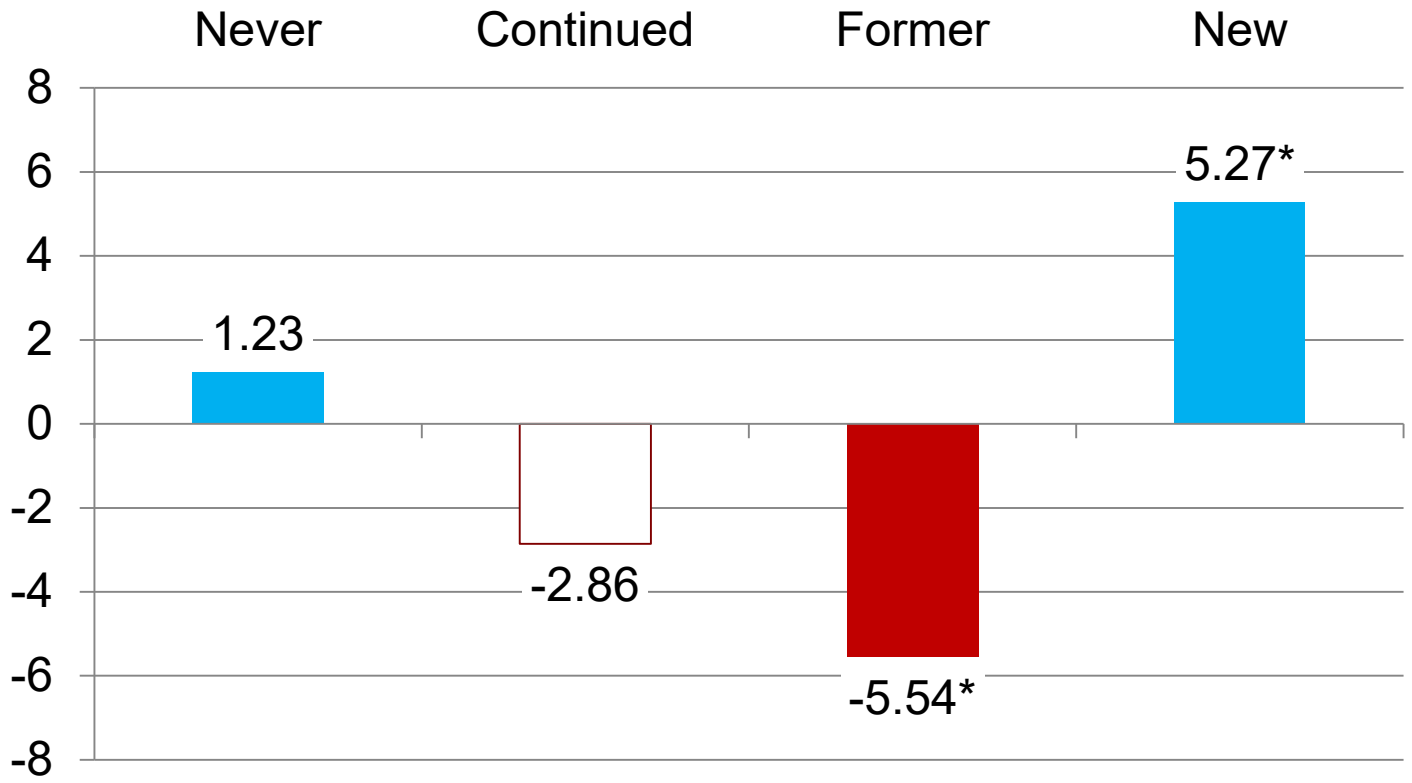
Real-world experiments

Hypotheses

New PA implies:	Public transit user group: Never	Continued	Former	New
i) no confounding	**No change** in PA-Other	**No change** in PA-Other	**Decrease** in PA-Transit	**Increase** in PA-Transit
ii) no substitution			**No increase** in PA-Other	**No decrease** in PA-Other
Net change in PA-Total	**No change**	**Any change**	**Decrease**	**Increase**

Changes in **PA-Total** time by group

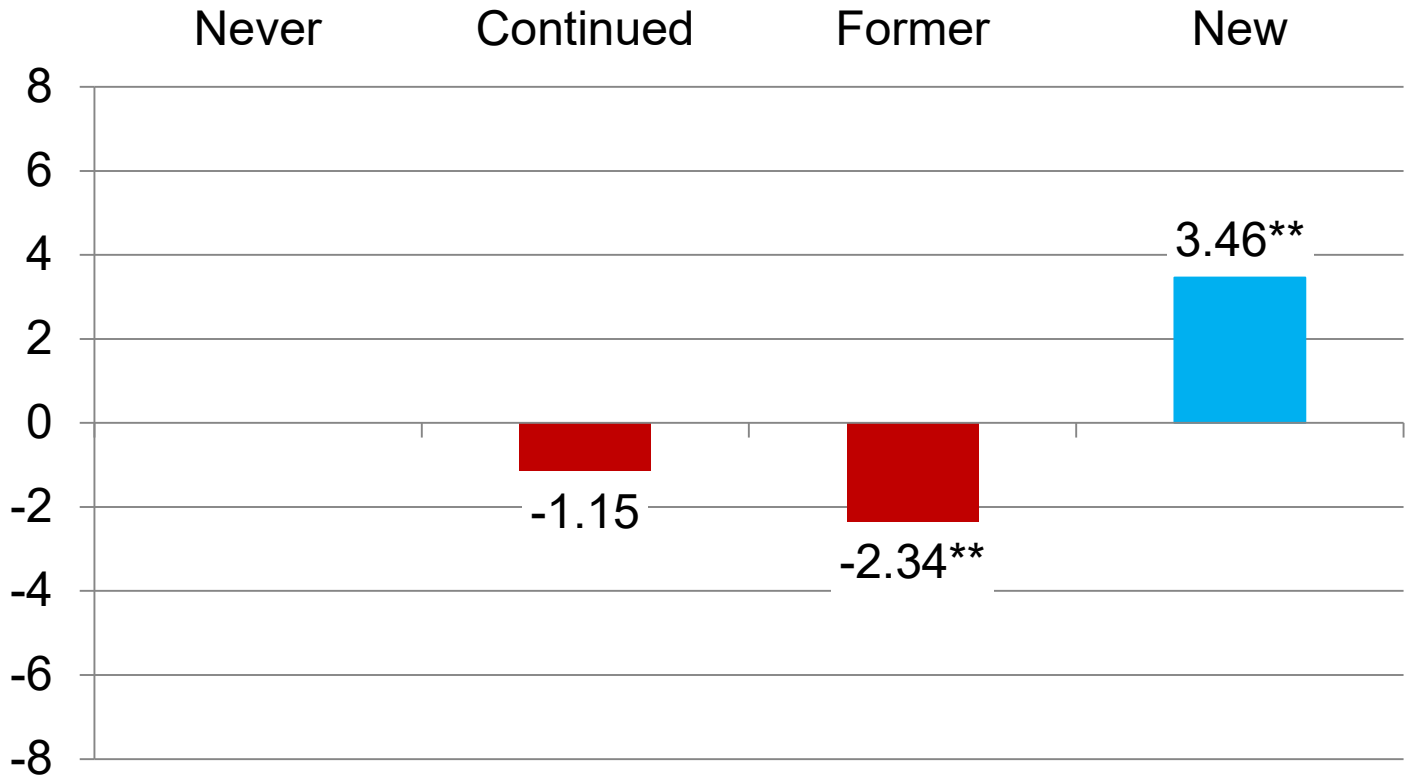
(within-person differences, 2013 - 2012)



Average time: Minutes per 10 hr. wear period
PA: Min 1000 cpm in min 5 minute bout
Within group differences: * $p < 0.1$

Changes in **PA-Transit** time by group

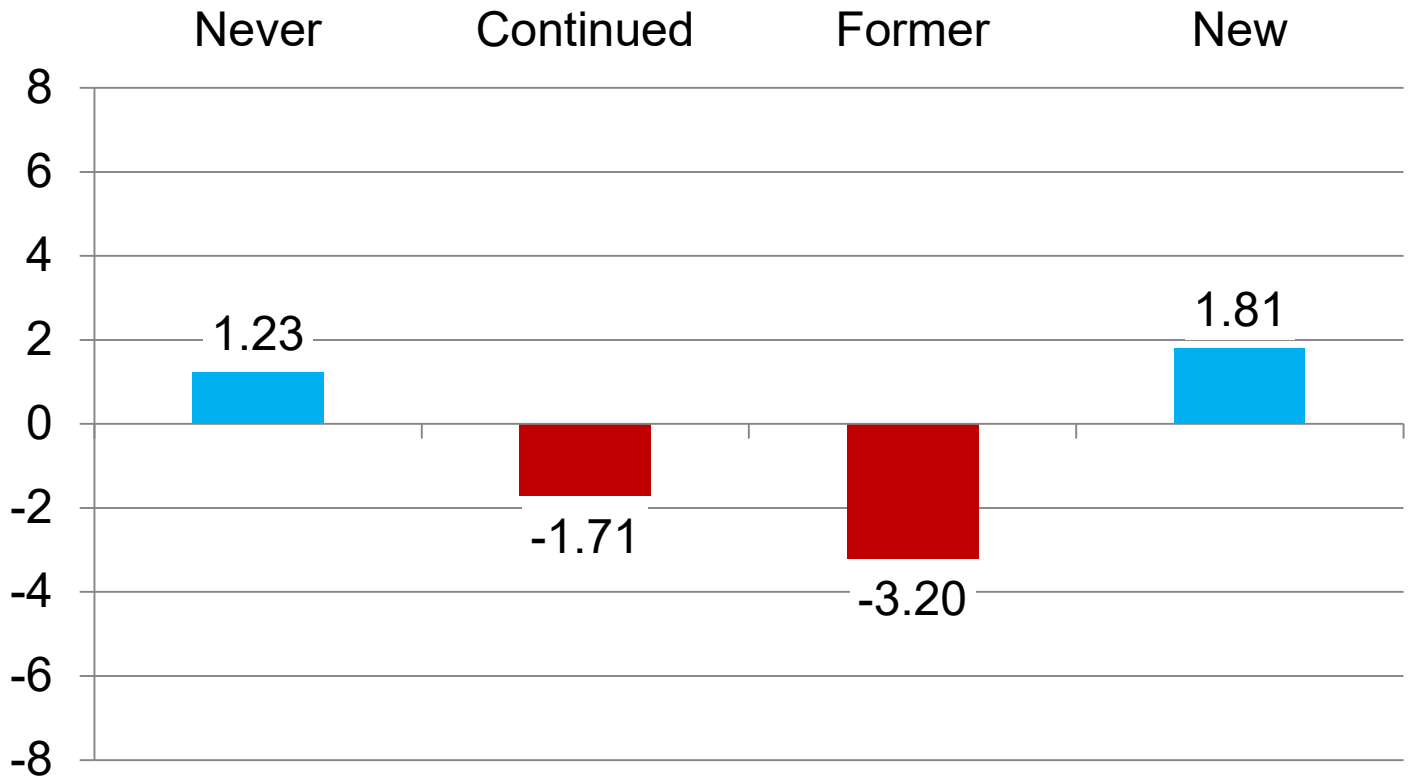
(within-person differences, 2013 - 2012)



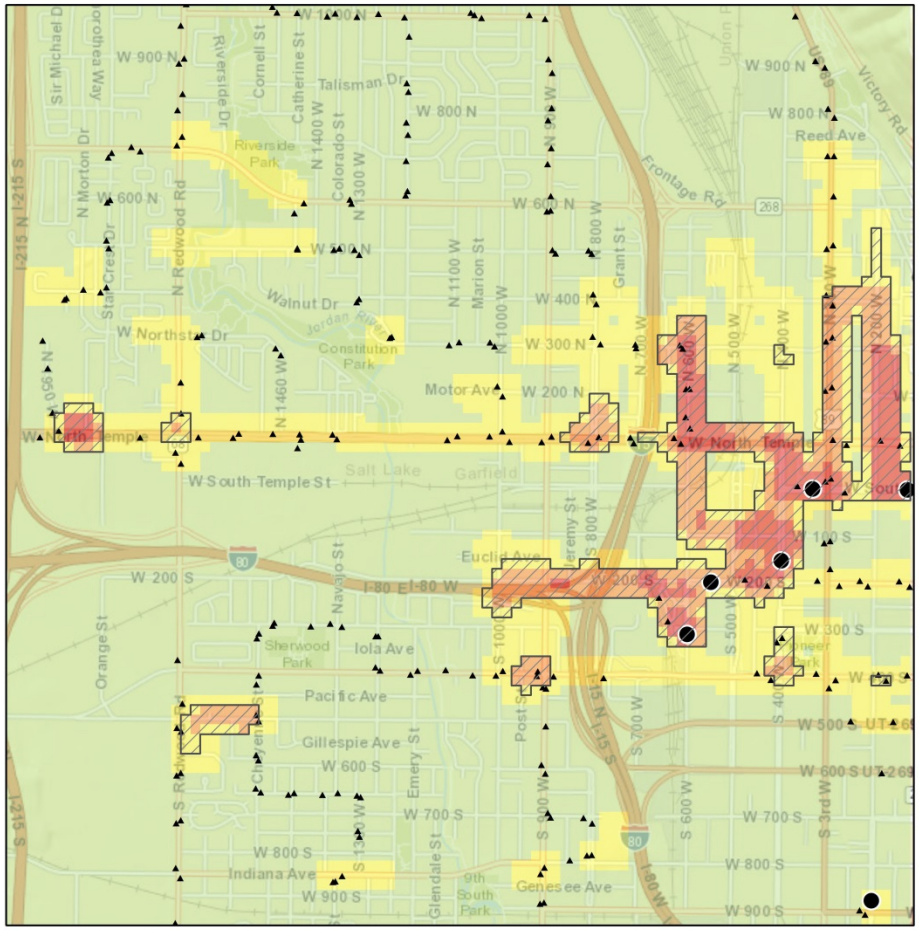
Average time: Minutes per 10 hr. wear period
PA: Min 1000 cpm in min 5 minute bout
Within group differences: ** $p < 0.05$

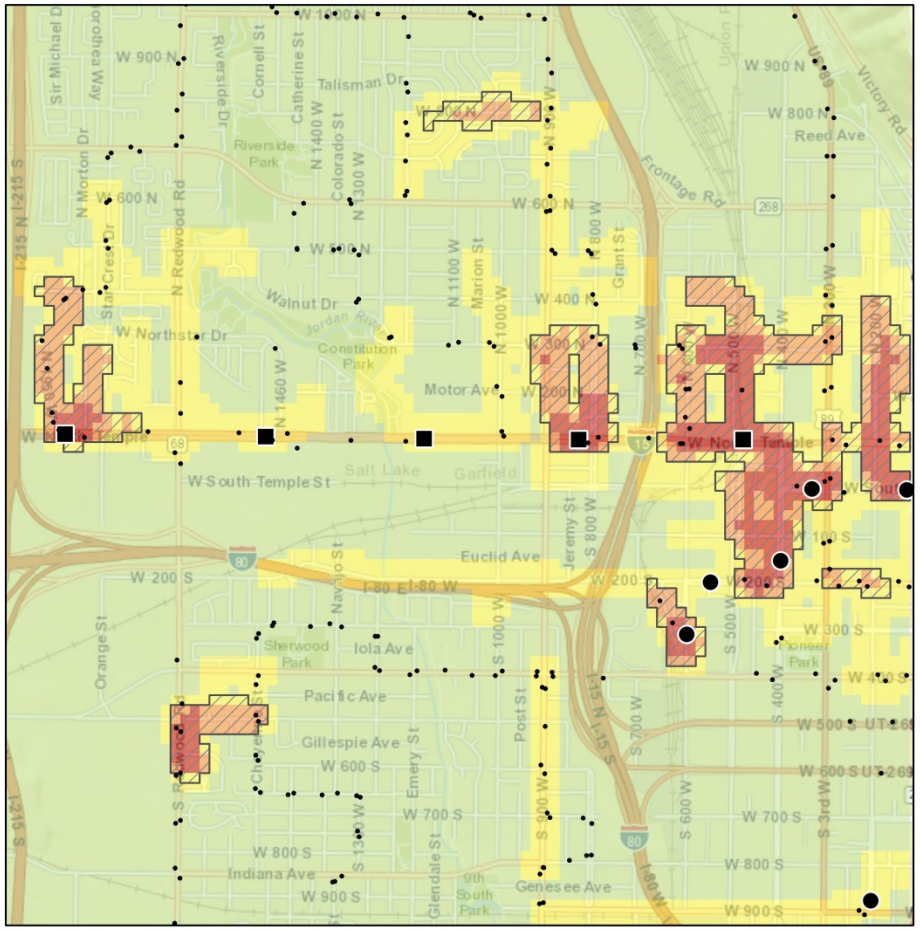
Changes in **PA-Other** time by group

(within-person differences, 2013 - 2012)



Average time (minutes per 10 hr. wear period);
PA: Min 1000 cpm in min 5 minute bout
Within group differences: None significant





2012 Transit-related Physical Activity

2013 Transit-related Physical Activity

- 2012 Bus Stops
- 2013 Bus Stops
- New TRAX Stations
- Existing TRAX Stations

- No GPS Points
- Low Density
- Medium Density
- High Density

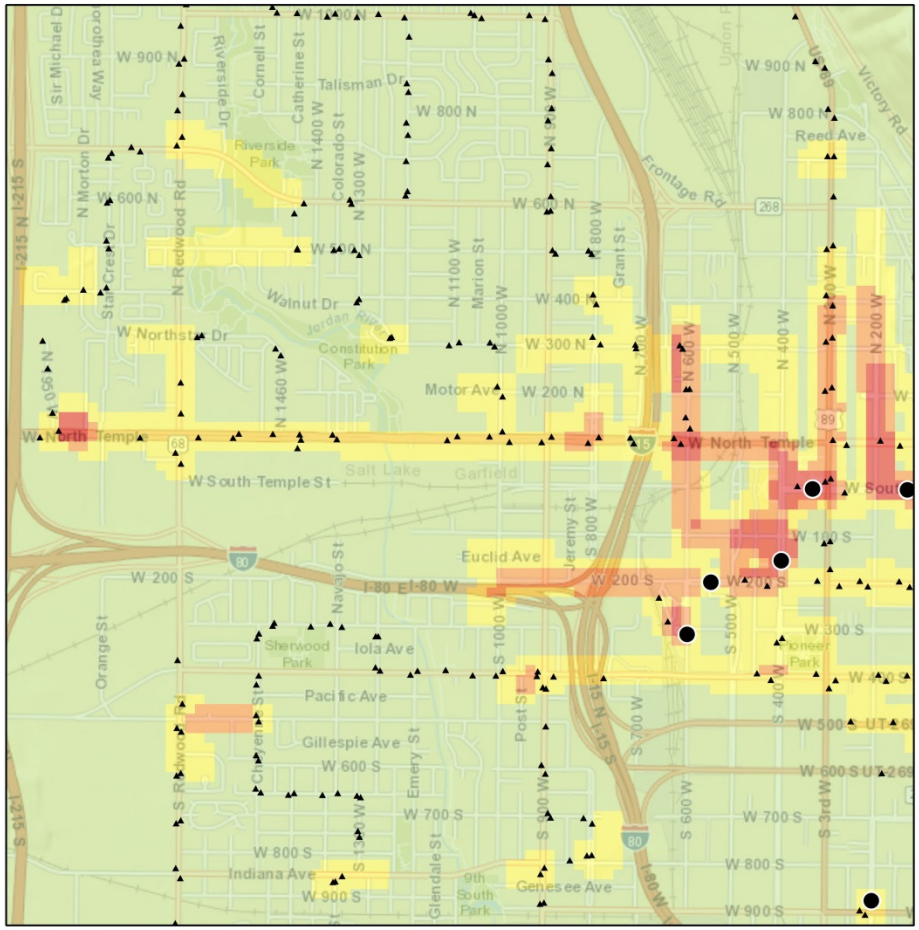
Local Moran's I

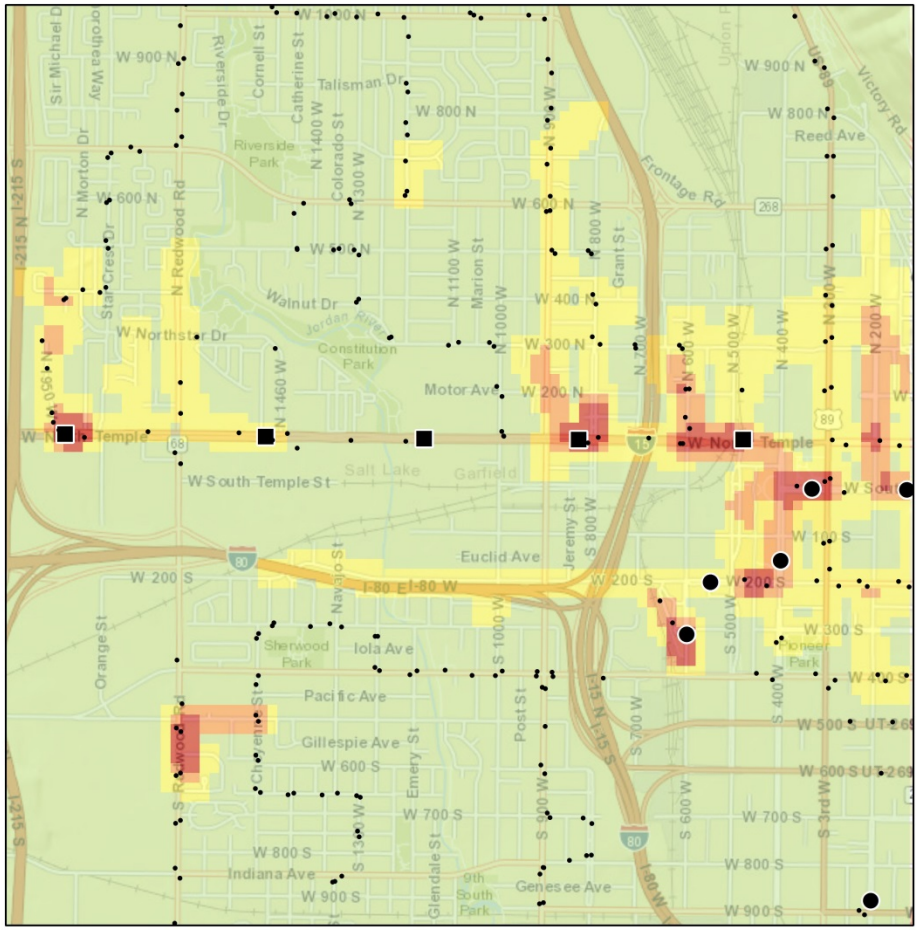
- Density Clusters

1

Kilometers

Basemap: Esri; Transit stops: AGRC.





2012 Transit-related Physical Activity CONTINUED

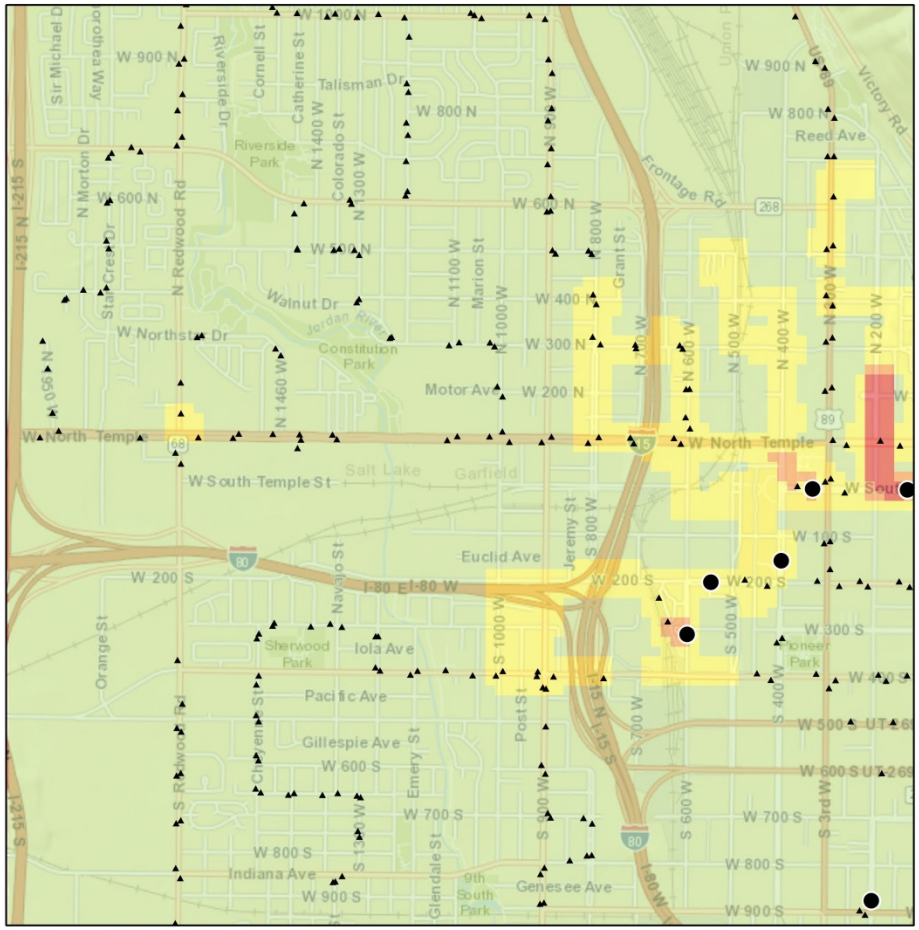
- 2012 Bus Stops
- 2013 Bus Stops
- New TRAX Stations
- Existing TRAX Stations

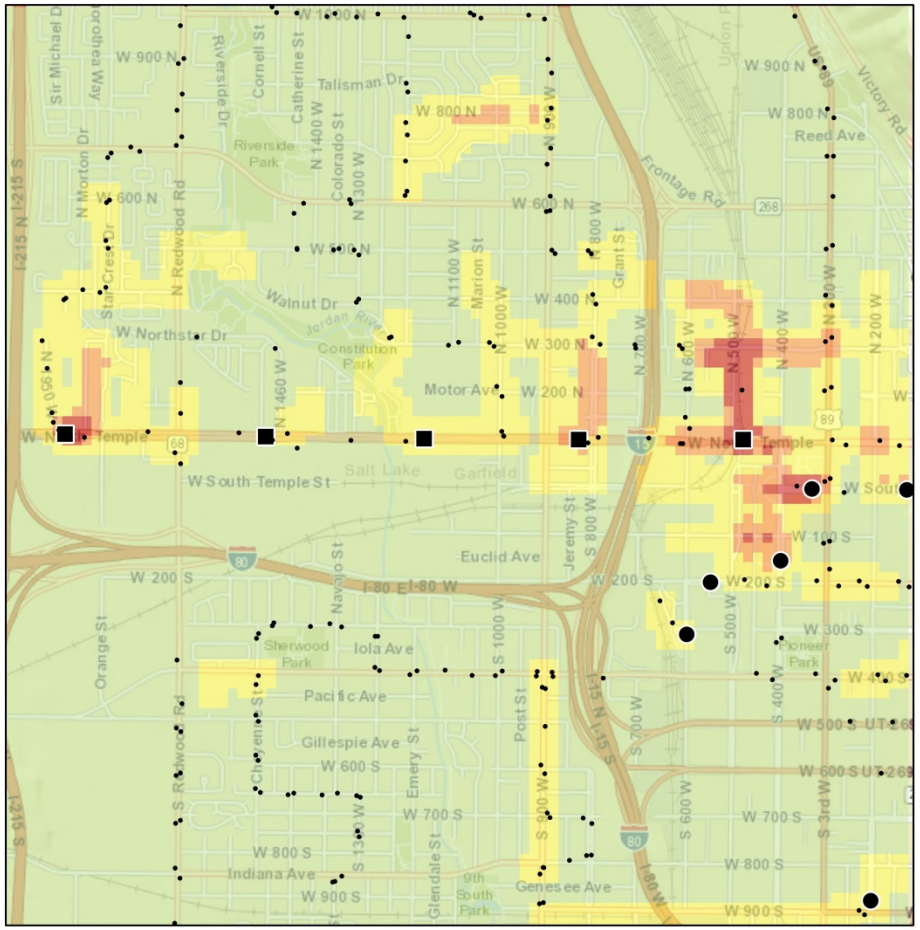
- No GPS Points
- Low Density
- Medium Density
- High Density

2013 Transit-related Physical Activity CONTINUED

Basemap: Esri; Transit stops: AGRC.

1 Kilometers





2012 Bus Stops
2013 Bus Stops
New TRAX Stations
Existing TRAX Stations

No GPS Points
Low Density
Medium Density
High Density

2012 Transit-related Physical Activity FORMER

2013 Transit-related Physical Activity NEW

Basemap: Esri; Transit stops: AGRC.

1
Kilometers

Summary

User behavior (2013 vs. 2012)	**PA-Total**	**PA-Transit**	**PA-Other**
Did not change (Never; Continuing)	No change	No change	No change
Stopped using transit (Former)	Decrease	Decrease	No change
Started using transit (New)	**Increase**	**Increase**	No change

No confounding factors

No substitution for non-transit PA

→ Transit PA is *new* PA!

Opportunistic GIScience

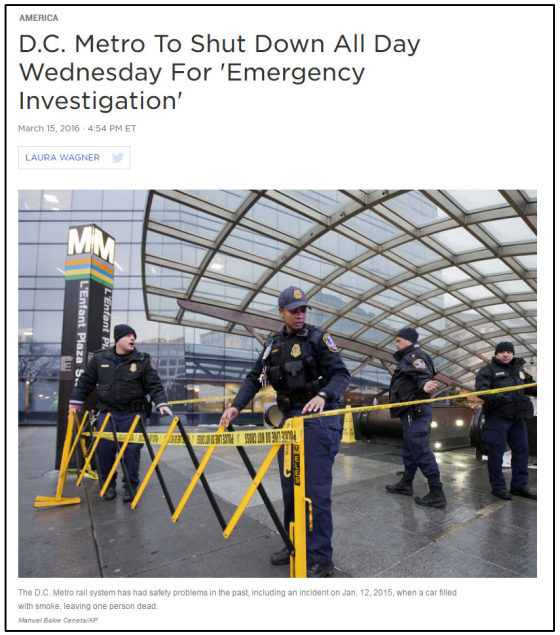
MAPS: a "one-off" experiment with a limited study horizon

Anticipated event

New LRT and street rehabilitation
Planned for years

Five-year study

No follow-up activity measurement


AMERICA

D.C. Metro To Shut Down All Day Wednesday For 'Emergency Investigation'

March 15, 2016 · 4:54 PM ET

LAURA WAGNER

The D.C. Metro rail system has had safety problems in the past, including an incident on Jan. 12, 2015, when a car filled with smoke, leaving one person dead.

Manuel Balce Ceneta/AP

What about unanticipated events?

What about policies with complicated outcomes and time horizons?

Opportunistic GIScience

Observatory science

What?

Ongoing data collection based on a favored view, supported by technology and organizational processes

http://www.brown.edu/

Why?

Discovery: Generate new, surprising hypotheses

Dynamics: Complex multi-scale dynamics

Monitoring and policy: e.g., volcano observatories

Ready when something happens!

Opportunistic GIScience

Human observatories

Social observatories

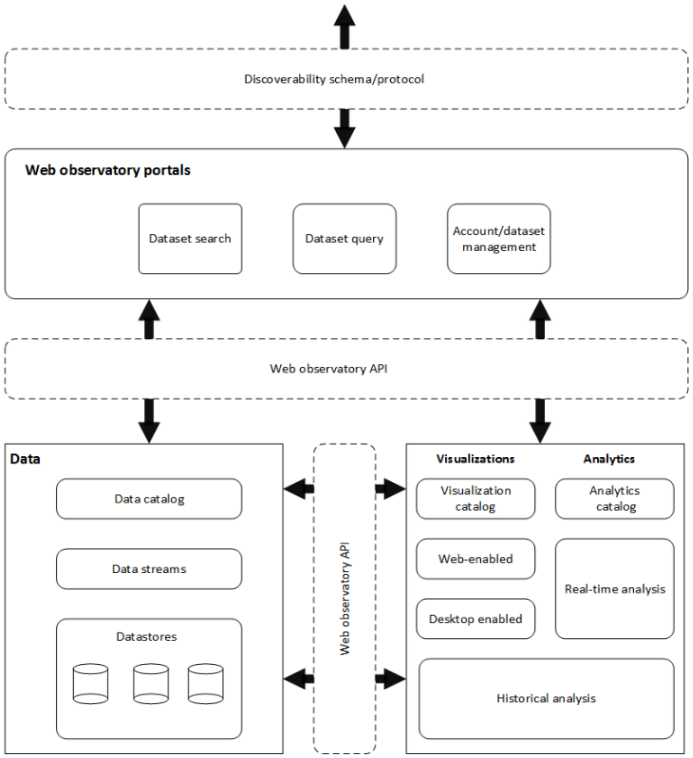
Collect and integrate data about social phenomena

Often focusing on a place or region

Web observatories

Collecting, sharing, querying and analysis of Web data

Middleware for ***broad data*** – complex data from diverse sources



Architecture for a real-time web observatory (Tinati et al. 2015)

Opportunistic GIScience

Geographic Information Observatories (GIOs)

What?

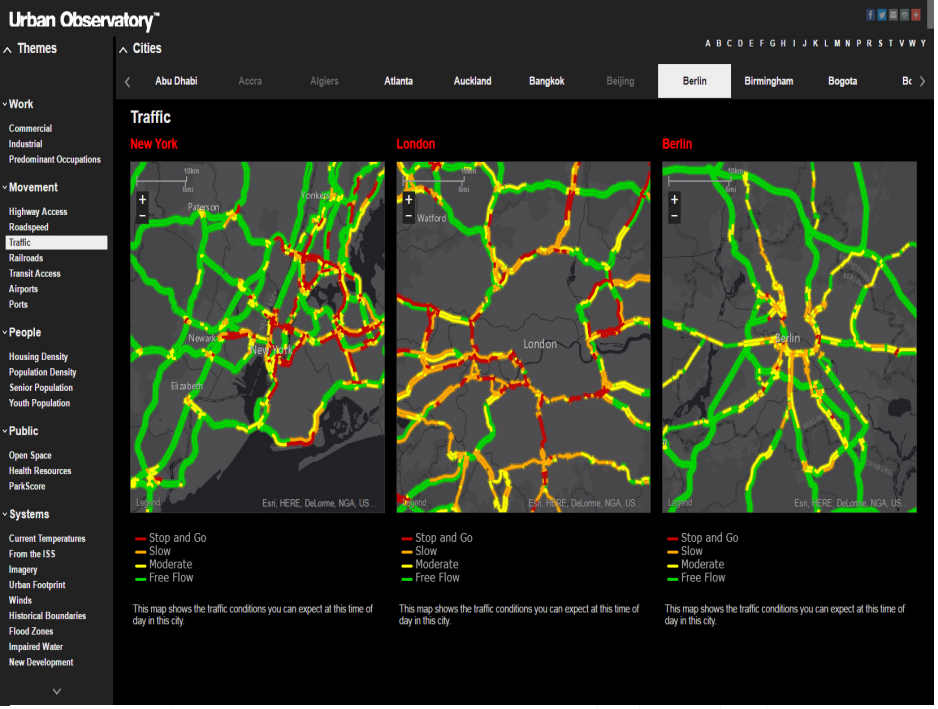
Integrate and analyze **broad geographic data** associated with a place or region

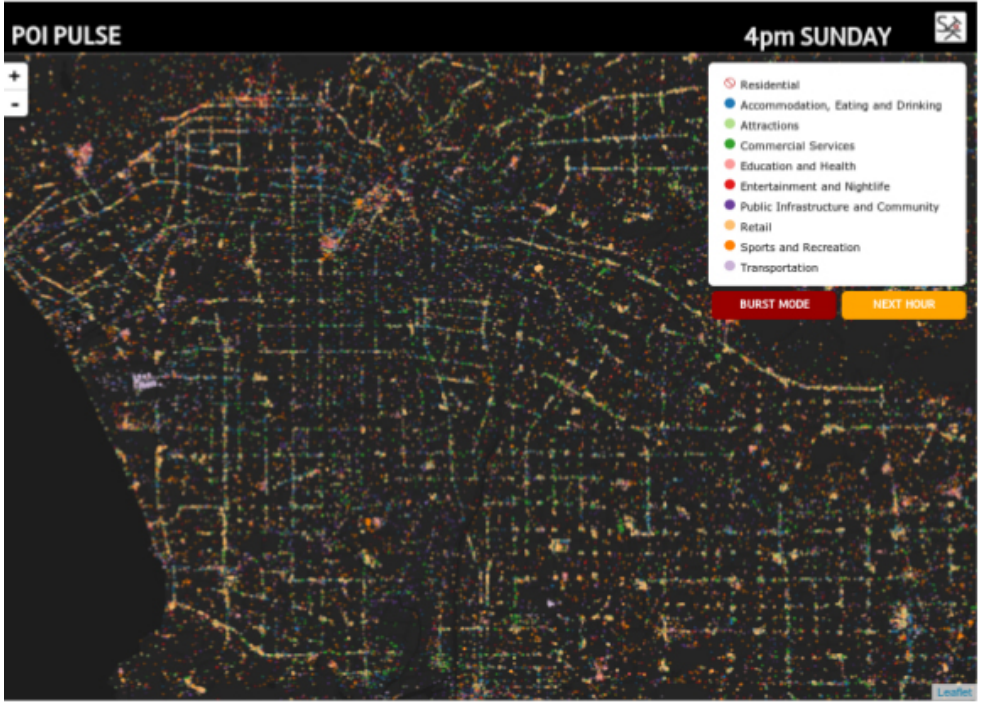
Why?

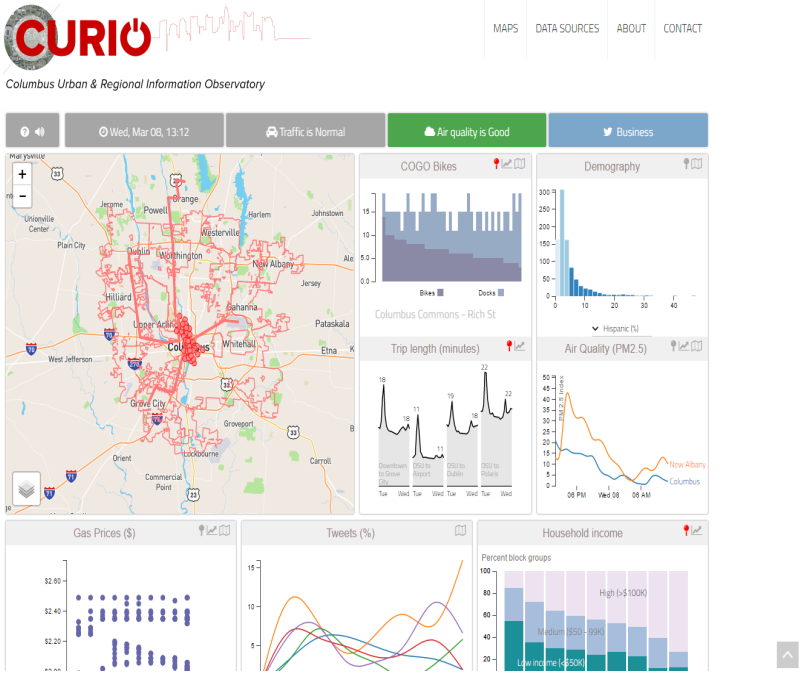
Observatory of geographic information (OGI): Explore and analyze the poorly understood geographic information universe

Geographic observatory (GO): Study the real world through the geographic information it produces and consumes

POI Pulse (McKenzie et al. 2015)







GIO examples

Upper left: Urban Observatory Project

Upper right: POI Pulse (McKenzie et al. 2015)

Lower left: Columbus Urban and Regional Information Observatory (CURIO)

Opportunistic GIScience

Geographic knowledge discovery, construction and use that leverages planned and unplanned events in the real world

Facilitated by GIO capabilities for persistent data collection and analysis

Three facets

1. Opportunistic observation
2. Opportunistic experiments
3. Opportunistic decision-making

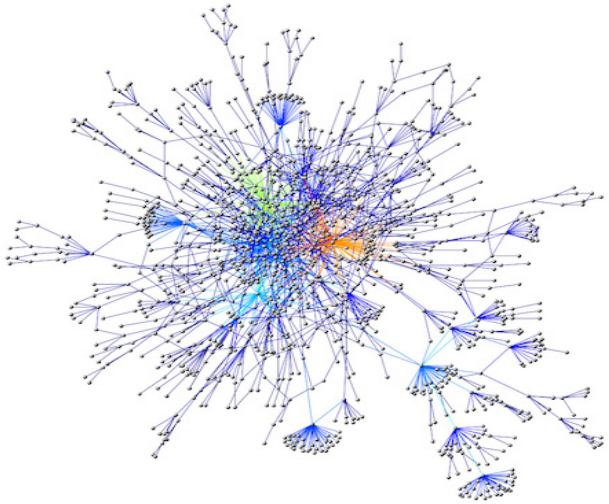
Opportunistic GIScience

Opportunistic observation

Human and coupled human-natural systems are complex

→ Geographic context matters!

→ History matters!



Ongoing, parallel observation is crucial

- Different geographic contexts
- Time periods sufficient to elucidate temporal dynamics
- Ready when surprises occur

Opportunistic GIScience

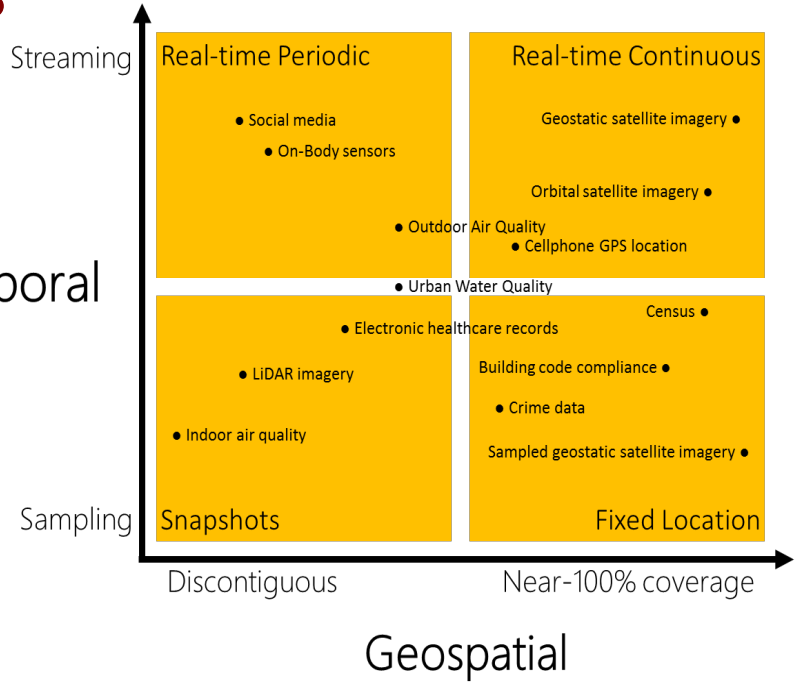
Opportunistic experiments

Leverage broad geographic data

Mundane events
Baseline measures

Unplanned events
Natural experiments

Complex policy outcomes
Non-binary outcomes
Multiple time horizons



Miller HJ and Tolle K (2016) "Big Data for healthy cities," *Built Environment,* 42, 441-456.

Opportunistic GIScience

Opportunistic decision-making

Learning from evidence can be slow with complex systems

- Despite lots of data!
- Feedback loops, delays, nonlinearities, self-organization and path dependence


www.futuretimeline.net

GIOs as virtual laboratories

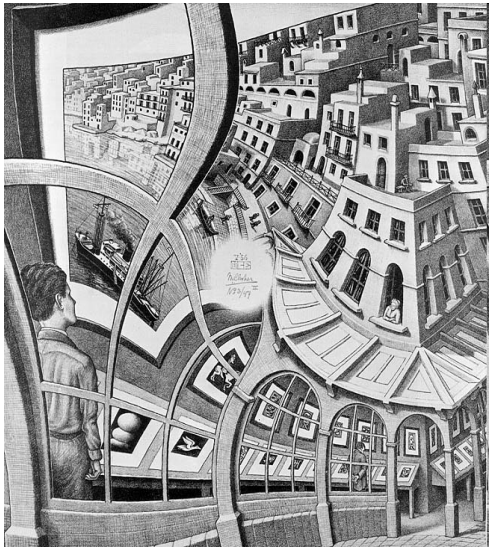
- Agent-based modeling and geosimulation
- Integrate empirical and simulated data
- Perform experiments infeasible in the real world

Opportunistic GIScience

GIOs as Mirror Worlds (Gelernter 1993)

Virtual reality **tightly coupled to the real-world** via streaming data

- A real-time, comprehensive, detailed, interactive and discoverable portrayal of a real-world system



MC Escher - "Print Gallery" (c) 2004 The M. C. Escher Company

Tool for **investigating** and **managing** reality

- Help scientists, leaders and citizens work together to understand and manage complex real world systems

Conclusion

Human systems are complex

- Policy interventions have unintended consequences
- Designing healthy places is a good example

Geographic data collection is much easier

- Allows researchers to design and execute real-world experiments, with stronger support for causality
- Opportunities for natural experiments are happening all the time!

Next step: Geographic information observatories

- Broad geographic data associated with a place or region
- Persistent observation and analysis supports opportunistic observation, experimentation and shared decision-making

Conclusion

Issues and concerns

Experimental ethics

Innocent real-world experiments?
Ask Facebook!

June 15, 2016 by Steve Kolowich

Facebook Reveals How It Decides if a Research Project Is Ethical

In 2014, Facebook came out as a player in social-science research, and a controversial one at that. Its "emotional contagion" experiment, in which the company tweaked the feeds of 700,000 users and studied how it affected their moods, drew harsh criticism and put pressure on the company to apply more scrutiny to its research projects.

Privacy

Differential privacy & indistinguishability
3D urban models as a metaphor and mechanism (Miller and Tolle 2016)

Data hubris

The parable of Google Flu (Lazer et al. 2014, *Science*, 343, 1203-1205)

Understand processes that generate data

Respect theory and administrative data

Thank you!

Papers (available at: u.osu.edu/miller.81)

Miller HJ (2017) "Geographic information observatories and opportunistic GIScience," ***Progress in Human Geography***, 41, 489-500.

Miller HJ and Tolle K (2016) "Big data for healthy cities: Using location-aware technologies, open data and 3D urban models to design healthier built environments," ***Built Environment***, 42, 441-456.

Miller HJ, Tribby CP, Brown BB, Smith KR, Werner CM, Wolf J, Wilson L and Oliveira MGS (2015) "Public transit generates new physical activity: Evidence from individual GPS and accelerometer data before and after light rail construction in a neighborhood of Salt Lake City, Utah, USA," ***Health and Place***, 36, 8-17.

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