Greening Cities to Promote Health Equity

Michael Jerrett, PhD
Professor and Chair
Department of Environmental Health Sciences
Fielding School of Public Health
University of California, Los Angeles

Map of the Talk

- Overview of reasons why green and blue space might improve health
- Evidence on specific health outcomes that have been related to contact with nature
- Look at evidence of environmental injustice from the Los Angeles region on access to parks and park quality
- Focus on physical activity and obesity in Los Angeles region in relation to parks and green areas

Nature and Health

- Growing evidence suggests that contact with natural areas in cities (green and blue spaces) has a wide range of human health benefits
- Evidence from Los Angeles suggests that access to green spaces and park is worse for low income areas and communities of color
- Quality of parks is also worse in the socially disadvantaged areas
- **Proposition**: If natural areas promote health, but access is unevenly distributed, then some of the population health inequities present in LA result from unequal access to green spaces, parks, and coastal areas

HUMAN TIMELINE

100000 BC

Hunter gatherers

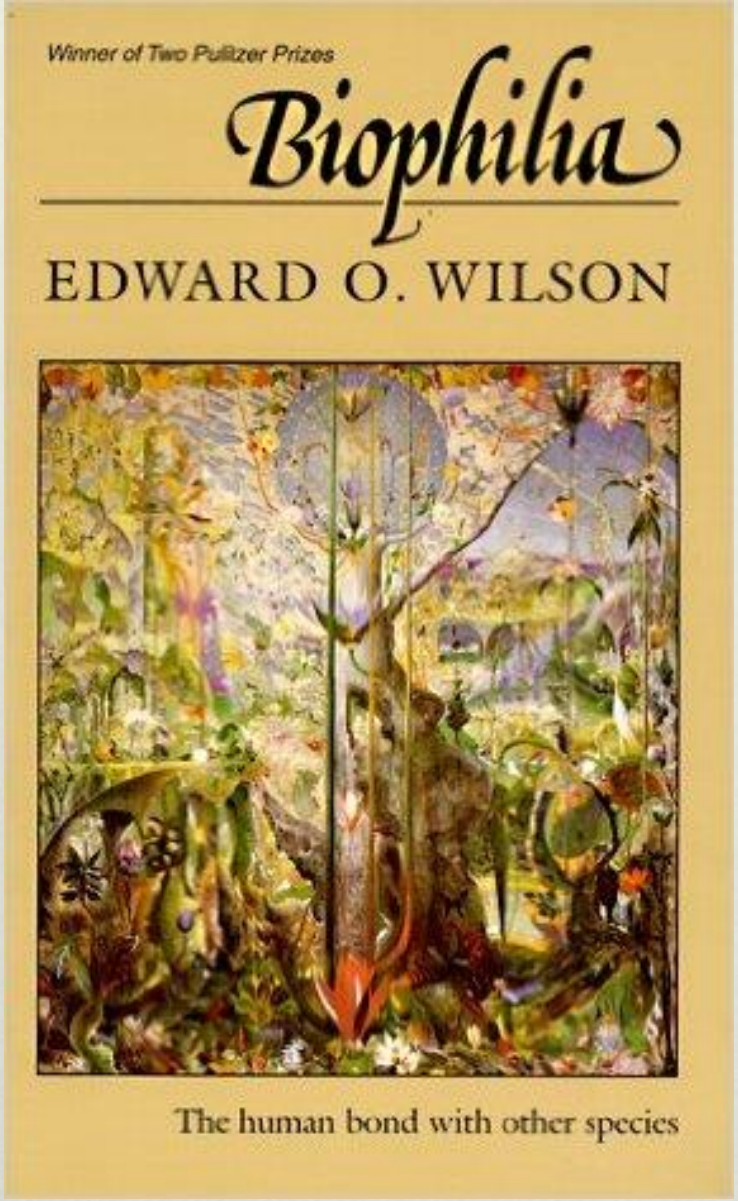
8000 BC

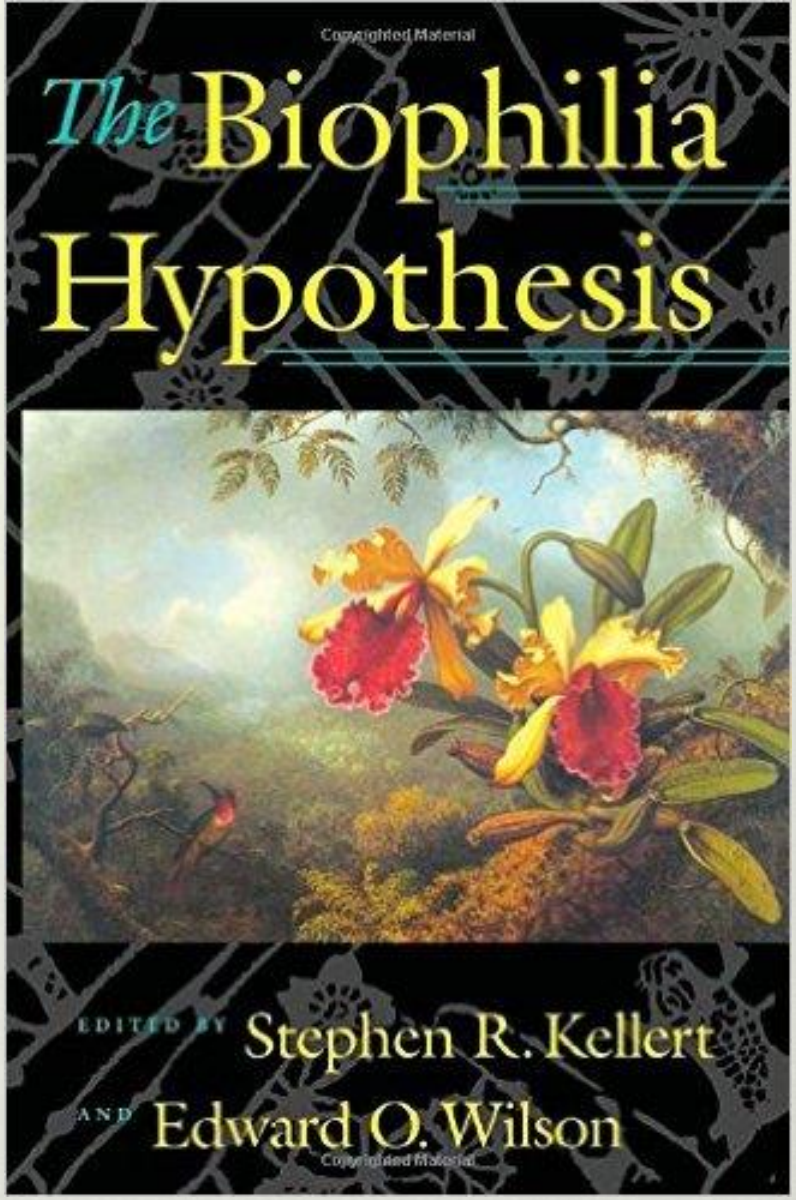
Agriculture

2000 AC

City dwellers

Slide courtesy of Dr. M. Nieuwenhuijsen





"Biophilia" is the term coined by Edward O. Wilson to describe what he believes is humanity's innate affinity for the natural world

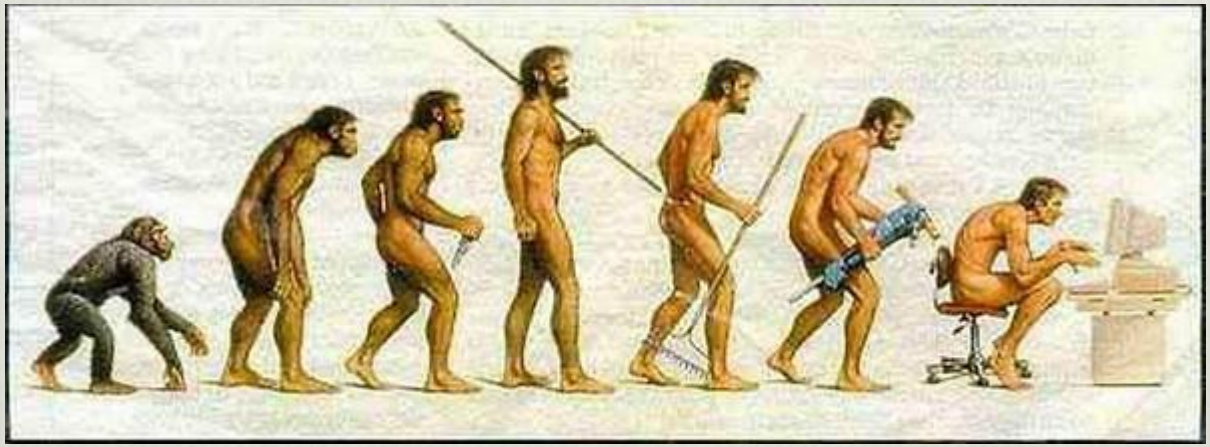
BIOPHILIA
(E.O. Wilson)

The inherent **love** for nature

Trust for nature, shelter and safety

Evolution – adapted to respond to natural stimuli, not to artificial input

Genetically **predisposed**



Slide courtesy of Dr. M. van den Bosch

STRESS REDUCTION THEORY

Roger Ulrich

- **Immediate** response to nature
- Non-conscious
- Physiological reactions – **stress recovery**, relaxation
- The **savannah** – vegetation, trees, and water, no threats
- We are **prepared to react to nature** but not to built settings

Savannah by glennaro_CC BY-NC-ND 2.0

Slide courtesy of Dr. M. van den Bosch

Ulrich, 1981, Ulrich, 1984 , Ulrich et al. 1991, Parsons et al. 1998, van den Berg & Custers, 2011

Kaplan & Talbot, 1983
Kaplan, 2001
Kaplan & Berman, 2010
Berman et al. 2012
White et al. 2013

ATTENTION RESTORATION THEORY

Rachel and Stephen Kaplan

- The universal meaning of nature to people
- General, positive value to everyone
- Cognitive mechanisms

Directed attention (energy demanding)

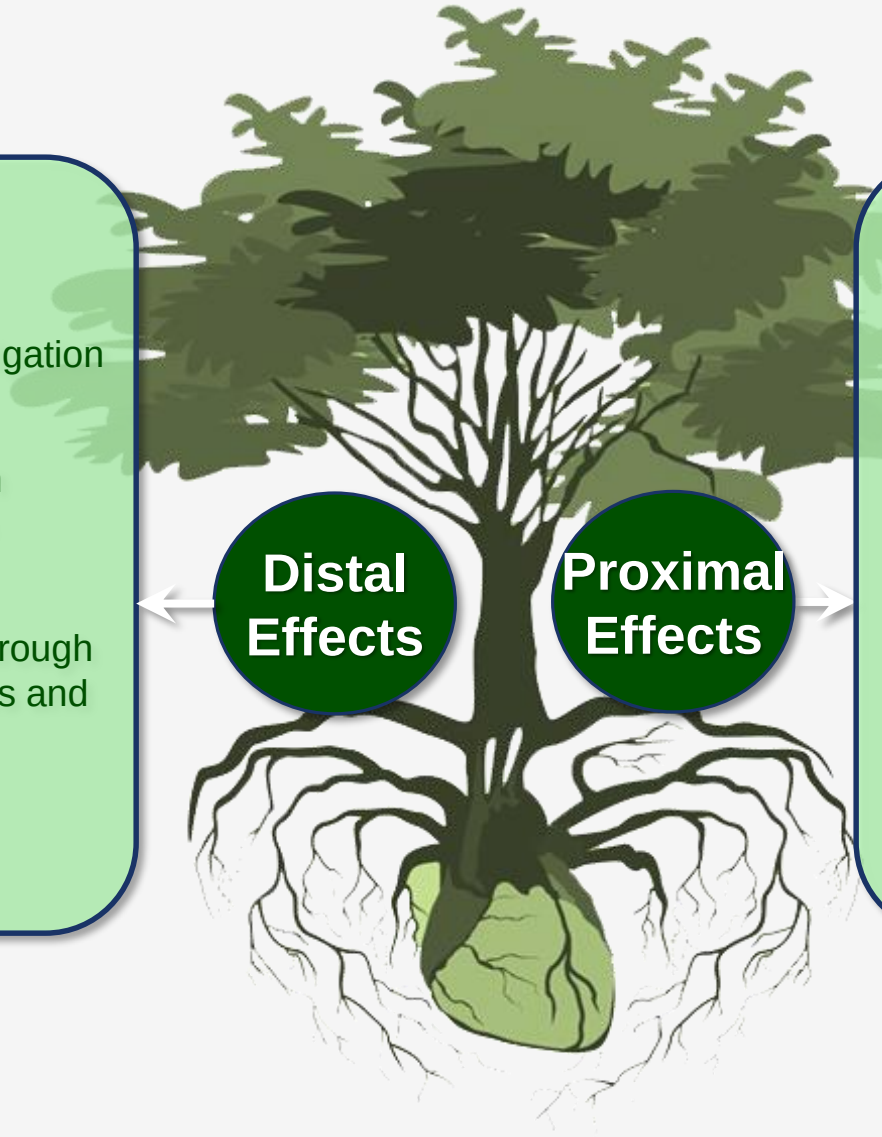
TIG Office by Yasmary_CC BY-NC-ND 2.0

Fascination (no effort)

Slide courtesy of Dr. M. van den Bosch

Pathways from Nature to Health

1. Climate Change Mitigation
2. Ecosystem Function Benefits to Humans
3. Economic Wealth through High Property Values and Tourism Potential



1. Increased Physical Activity and Reduced Obesity
2. Increased Benefits of Physical Activity when in Nature
3. Mental and Physical Health Benefits (Stress Reduction Theory / Attention Restoration Therapy)
4. Buffering Capacity (Heat, Noise, Air Pollution, Micro-biome)
5. Increased Opportunity for Social Interaction

AN INCREASING NUMBER OF STUDIES SHOW VARIOUS HEALTH EFFECTS OF EXPOSURE TO GREEN SPACE

REDUCED

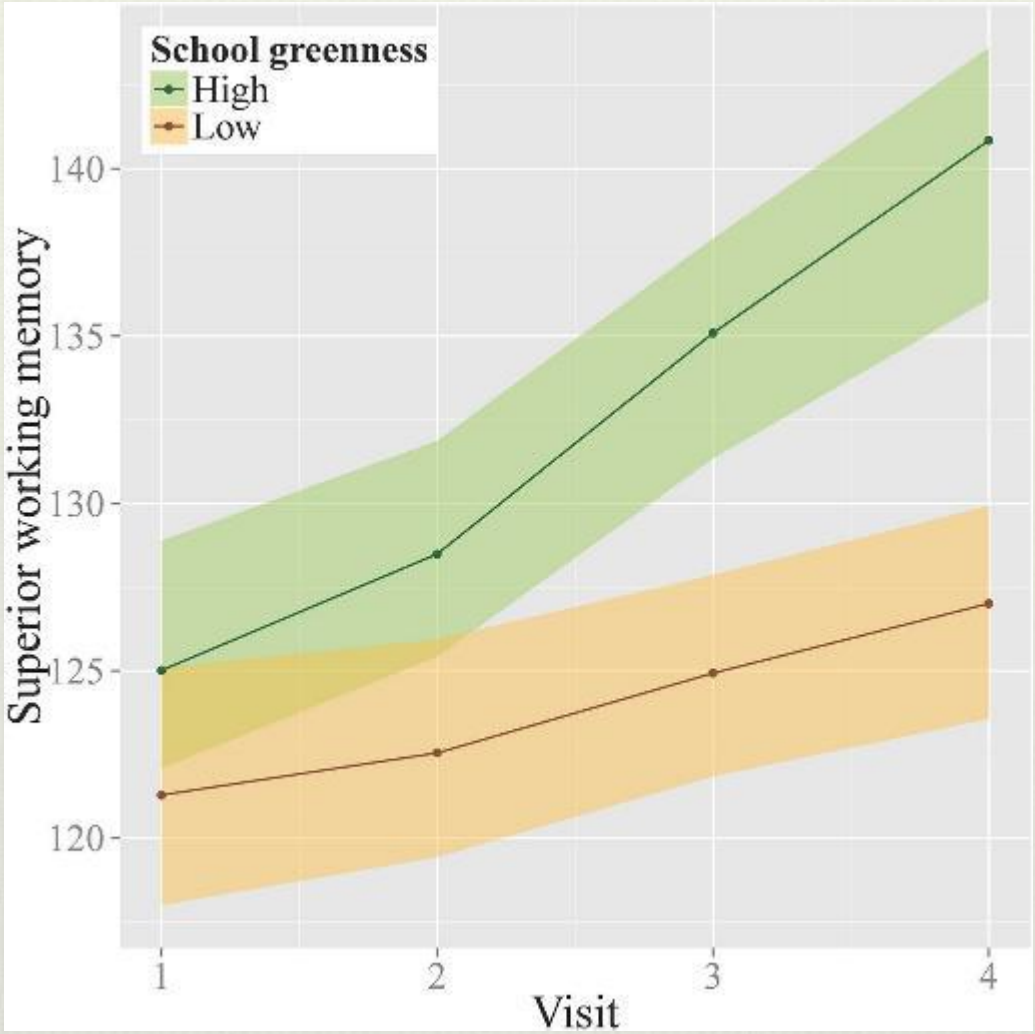
- symptoms of **ADHD** (e.g. *Kuo & Taylor, 2004*)
- **Mortality** (e.g. *Villeneuve et al.2013; Crouse et al. 2018*)
- **Cardiovascular** and **respiratory illness** (e.g. *Tamosiunas et al. 2014*)
- **Depression (***e.g. McEachan et al. 2016; South et al. 2018)*

IMPROVED

- **pregnancy outcomes** (e.g. *Hystad et al. 2014; Dadvand et al. 2014*)
- **wellbeing** and **happiness** *(e.g. MacKerron & Mourato, 2013)*
- **Cognitive development and brain function** *(e.g. Dadvand et al. 2015; Dadvand et al. 2016)*
- **Academic performance** *(e.g. Sivarajah 2018)*

Slide modified from Dr. M. van den Bosch

Better cognitive development among children who go to schools in green areas



PNAS

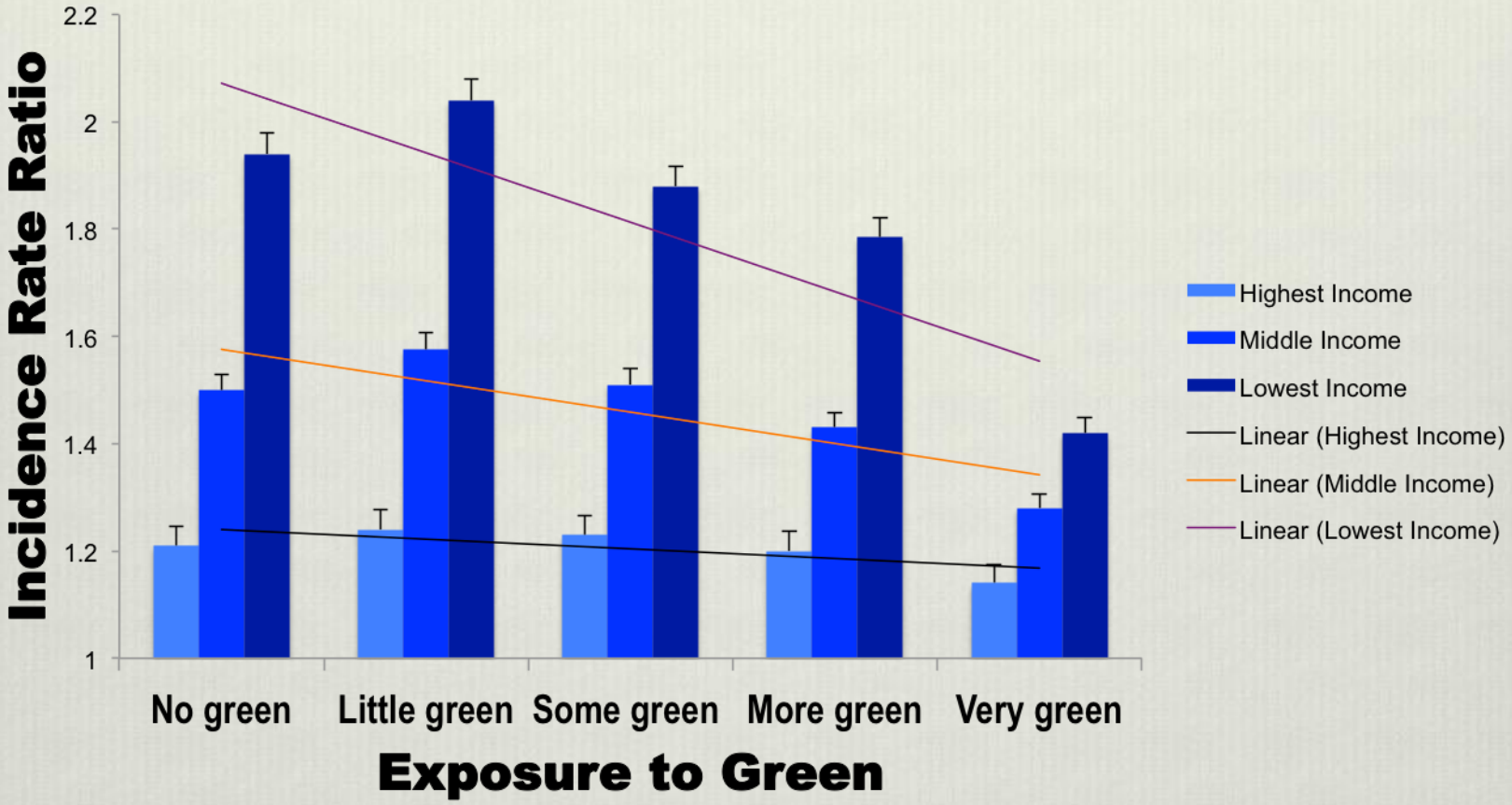
CrossMark

Green spaces and cognitive development in primary schoolchildren

Payam Dadvand[a,b,c,1], Mark J. Nieuwenhuijsen[a,b,c], Mikel Esnaola[a,b,c], Joan Forns[a,b,c,d], Xavier Basagaña[a,b,c], Mar Alvarez-Pedrerol[a,b,c], Ioar Rivas[a,b,c,e], Mónica López-Vicente[a,b,c], Montserrat De Castro Pascual[a,b,c], Jason Su[f], Michael Jerrett[g], Xavier Querol[c], and Jordi Sunyer[a,b,c,h]

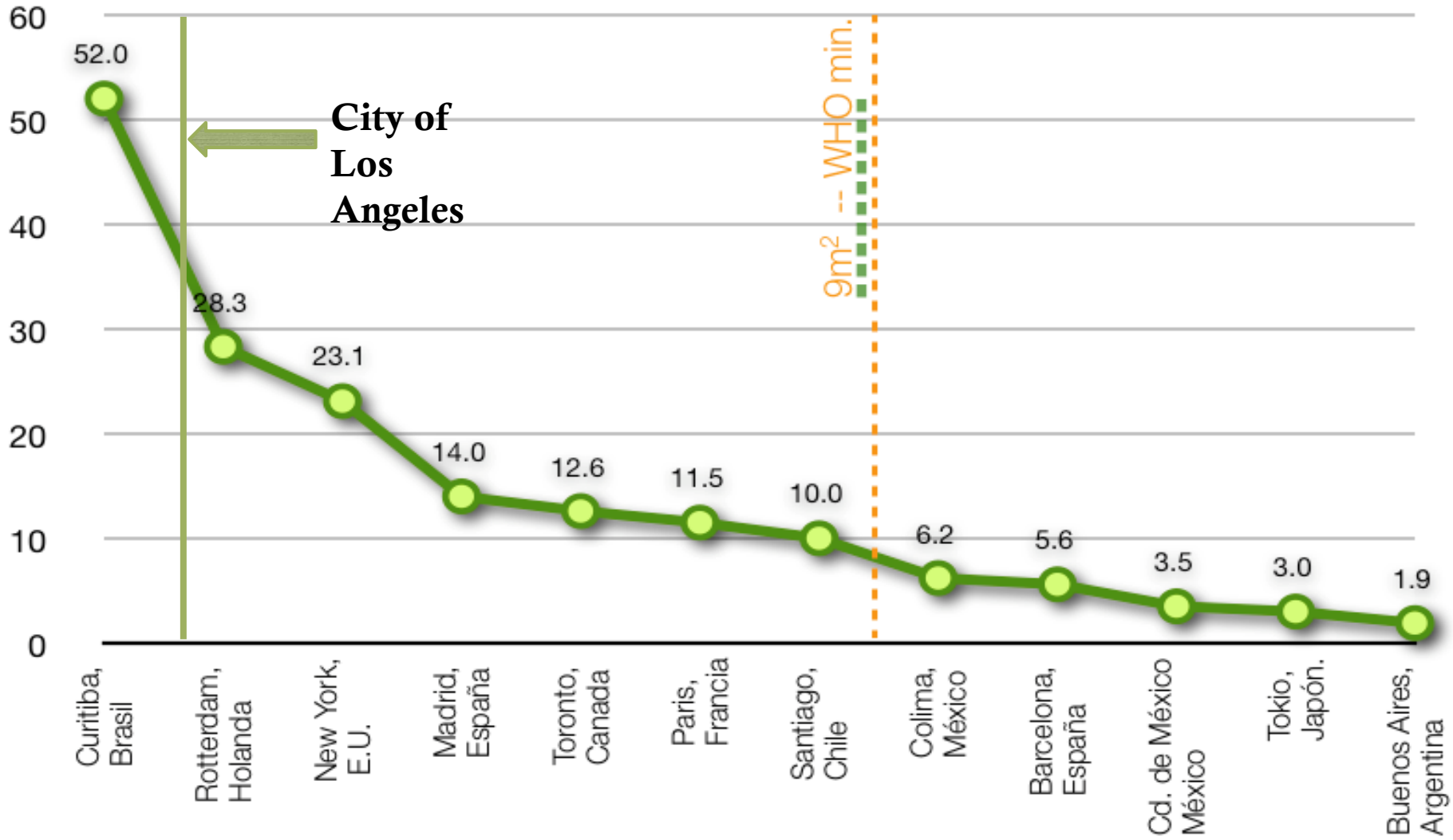
[a]Centre for Research in Environmental Epidemiology (CREAL), 08003 Barcelona, Spain; [b]Experimental and Health Sciences, Pompeu Fabra University, 08003 Barcelona, Catalonia, Spain; [c]Ciber en Epidemiología and Public Health (CIBERESP), 28029 Madrid, Spain; [d]Department of Genes and Environment, Division of Epidemiology, Norwegian Institute of Public Health, 0473, Oslo, Norway; [e]Department of Geosciences, Institute of Environmental Assessment and Water Research, Spanish National Research Council (CSIC-IDEA), 08034 Barcelona, Catalonia, Spain; [f]Environmental Health Sciences, School of Public Health,

INEQUALITIES IN CARDIOVASCULAR MORTALITY DUE TO SOCIOECONOMIC POSITION ARE MUCH SMALLER IN GREEN AREAS



Mitchell and Popham, 2008. The Lancet

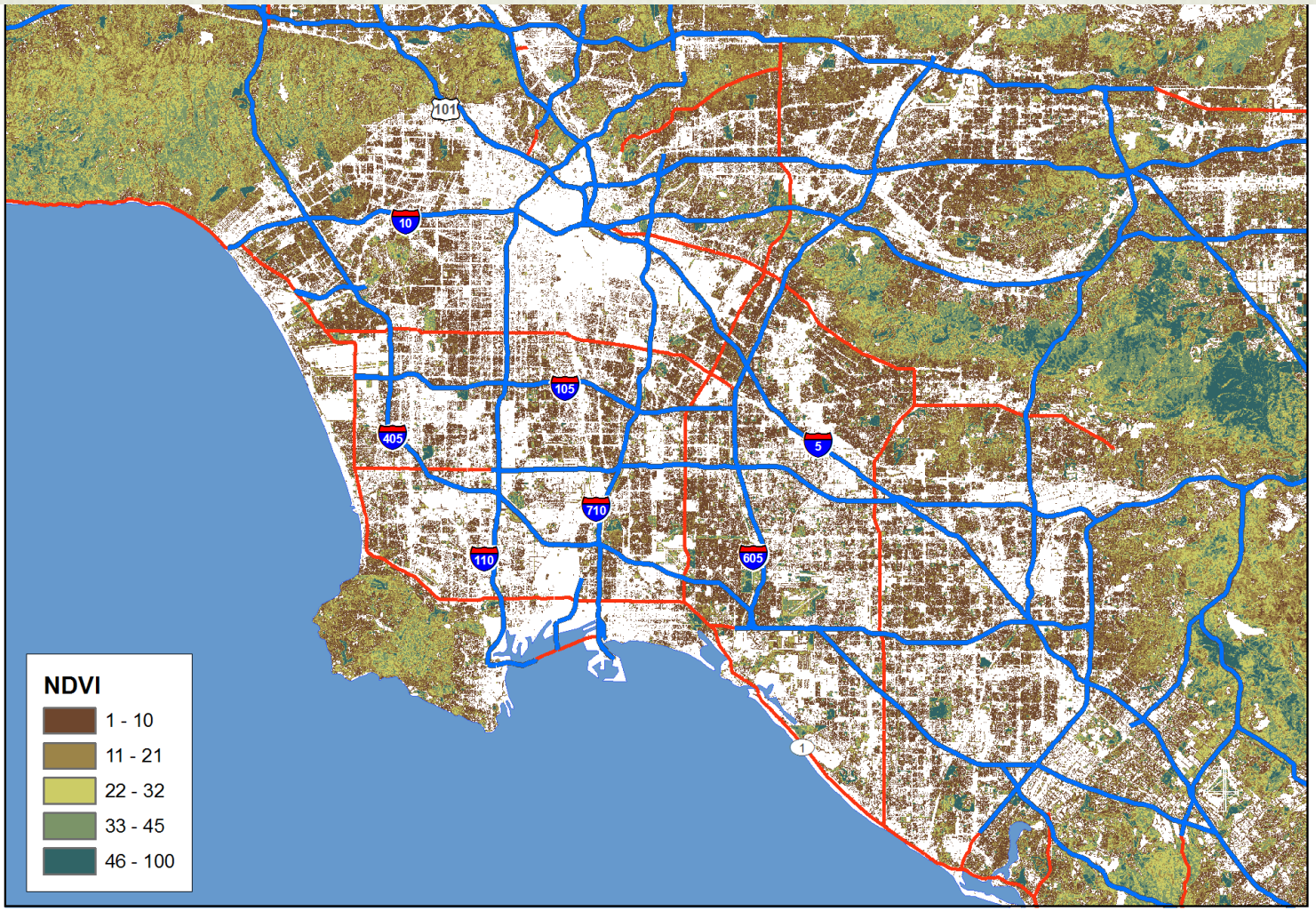
M^2 of green space per person of the world



Remote-Sensing Indicator of Vegetation Greeness in LA

Normalized Difference Vegetation Index from Landsat

= (NIR –RED) / (NIR +RED)



South Central Los Angeles: Little Green Space

Comparison of Park Supply by Various Social Groups Los Angeles

Racial-Ethnic Group	Acres per 1000 Population	Acres per 1000 Children	Percent with access in ¼ mile	Children with no easy access
Total	7.3	26.7	29	700,643
Latino	1.6	5.1	33	500,000
African American	0.8	2.9	33	50,000
White	17.4	95.7	22	183,000

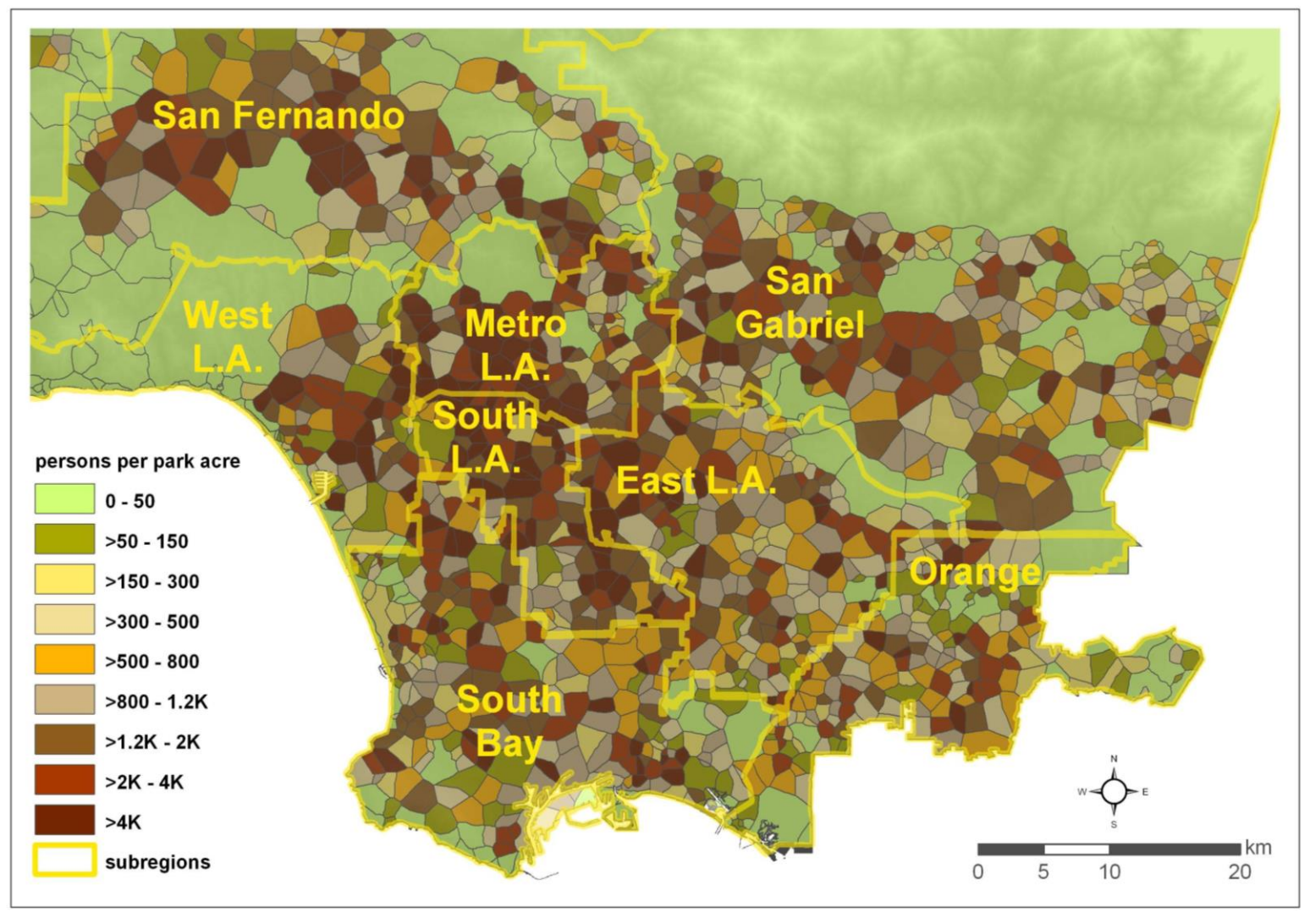
Data supplied from Jennifer Wolch Green Visions Program 2014 year

Park Access by Income and Poverty

- Lowest income areas – 0.5 acres/1,000 population
- Highest income areas – 21.2 acres/1,000 population

- Highest poverty areas – 1 acre/1,000 population
- Lowest poverty areas – 18.9 acres/1,000 population

Park Pressure Levels Across Los Angeles Region



Evidence on Inequality in Park Access and Quality Programming

- Park access and recreational programming associated with lower obesity in children (Wolch, Jerrett et al. 2010), but many people lack either or both
- In Los Angeles, poor communities and communities of color have lower access to parks programming (Dahmann et al. 2009) and to park areas (Sister et al. 2010)
- Parks also have worse air pollution in disadvantaged areas (Su, Jerrett et al. 2010), with Latino's getting 150% higher inhaled doses
- Parks in poor areas and neighborhoods with high Latino populations have much greater traffic risks near the parks than in wealthier areas with predominantly white populations (Jerrett et al. 2017) – 50% higher risk of getting hit

GREEN SPACE AND PHYSICAL ACTIVITY

Social Science & Medicine 138 (2015) 22–30

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Review

Association of proximity and density of parks and objectively measured physical activity in the United States: A systematic review

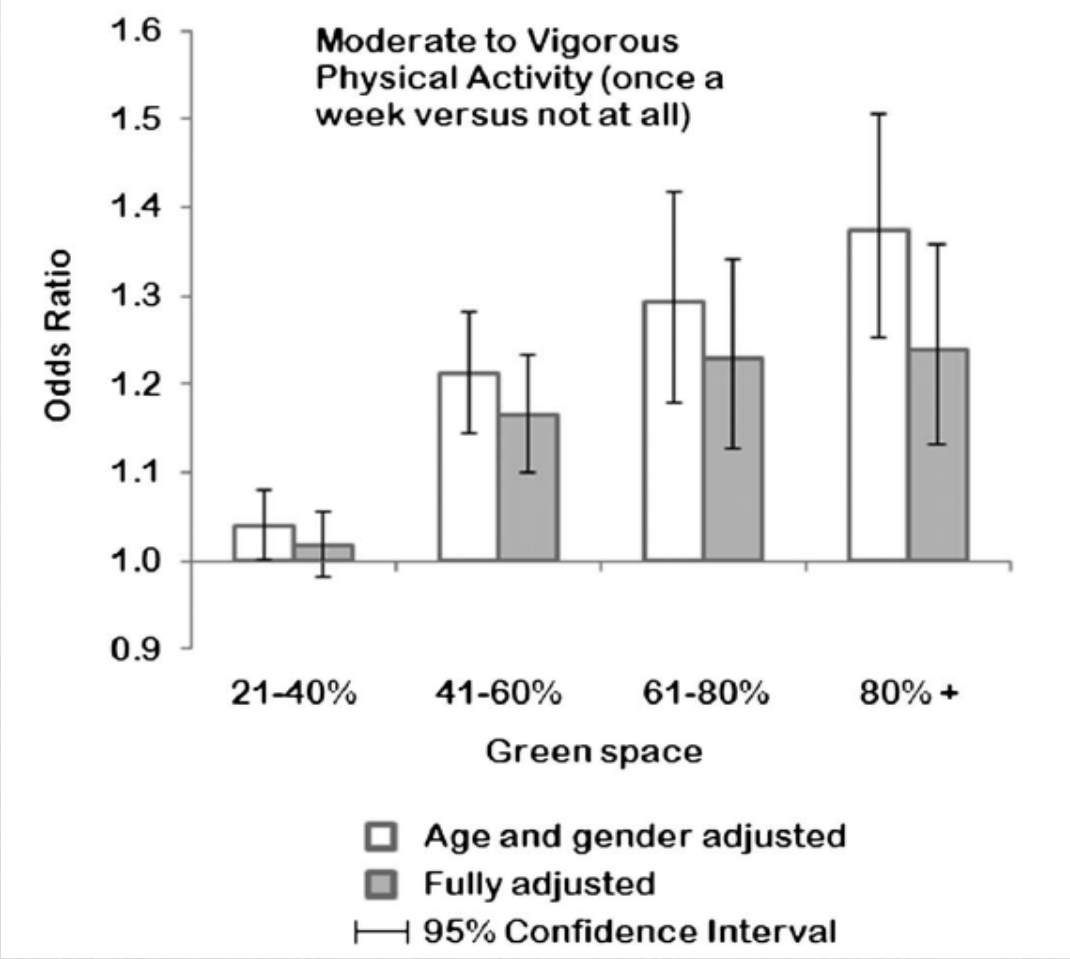
Carolyn Bancroft [a, *], Spruha Joshi [a], Andrew Rundle [a], Malo Hutson [b], Catherine Chong [d], Christopher C. Weiss [c], Jeanine Genkinger [a], Kathryn Neckerman [d], Gina Lovasi [a]

20 articles met the inclusion criteria. Five articles reported a significant positive association between parks and physical activity. Nine studies found no association, and six studies had mixed findings.

Our review found that even among studies with objectively measured physical activity, the association between access to parks and physical activity varied between studies, possibly due to heterogeneity of exposure measurement. Self-reported (vs. independently-measured) neighborhood park environment characteristics and smaller (vs. larger)

buffer sizes were more predictive of physical activity.

GREEN SPACE AND PHYSICAL ACTIVITY



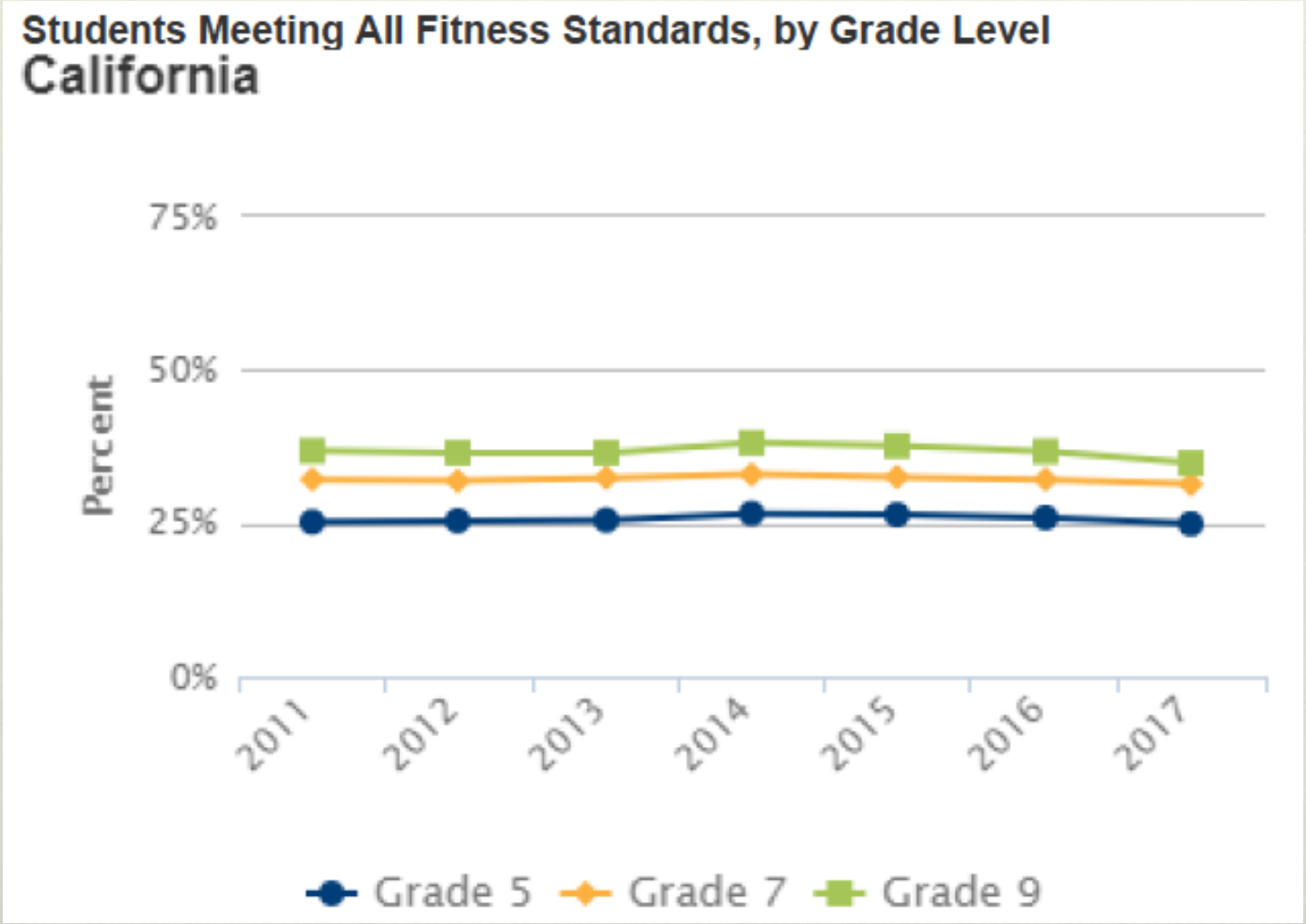
N=203883 adults

Astell-Burt et al 2014

A study of community design, greenness, and physical activity in children using satellite, GPS and accelerometer data

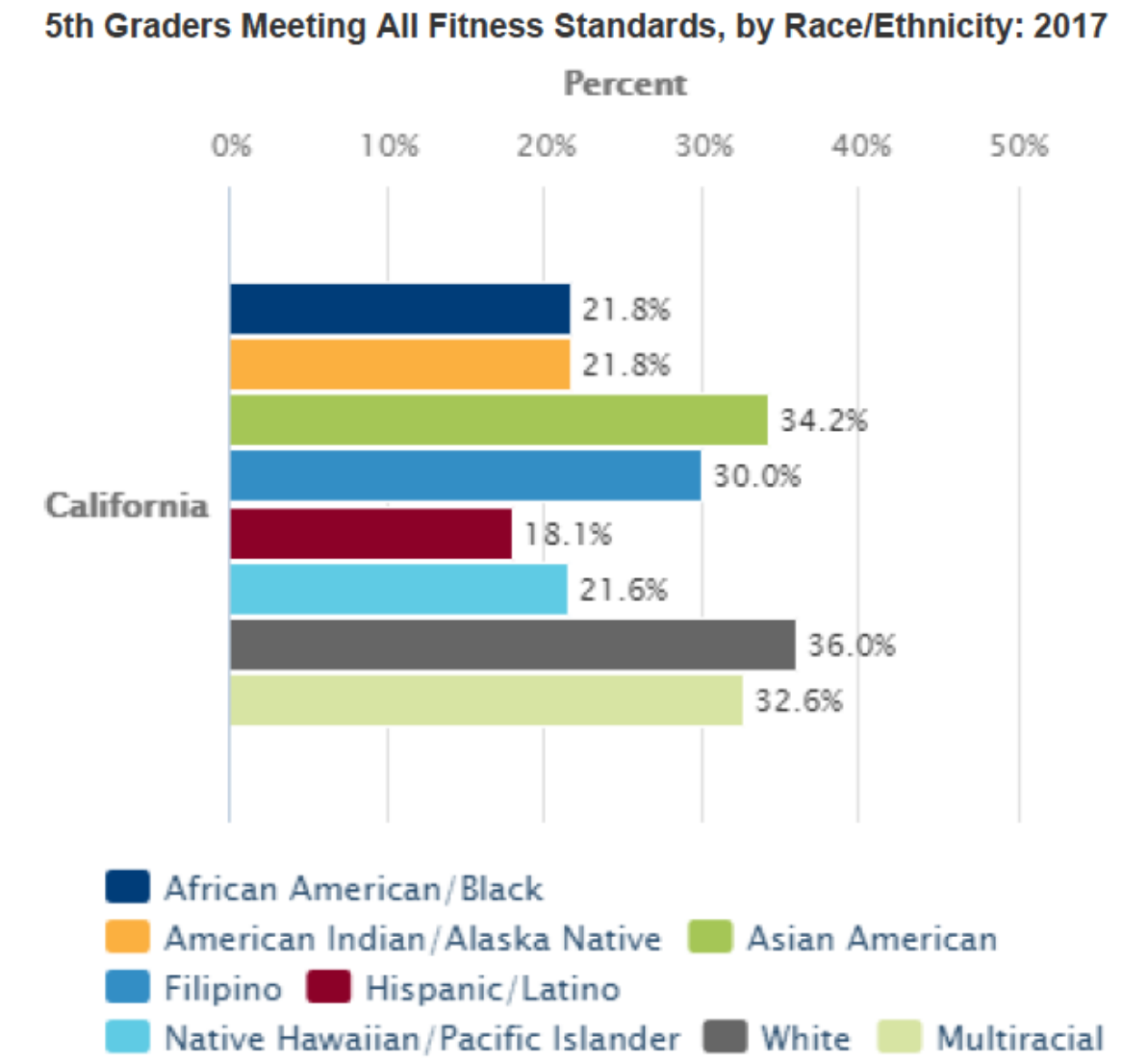
Estella Almanza, MPH, Michael Jerrett, PhD

Most Children Fail to get recommended Physical Activity



Kiddata.org 2017

Big Differences by Race-Ethnicity



Kiddata.org
2017

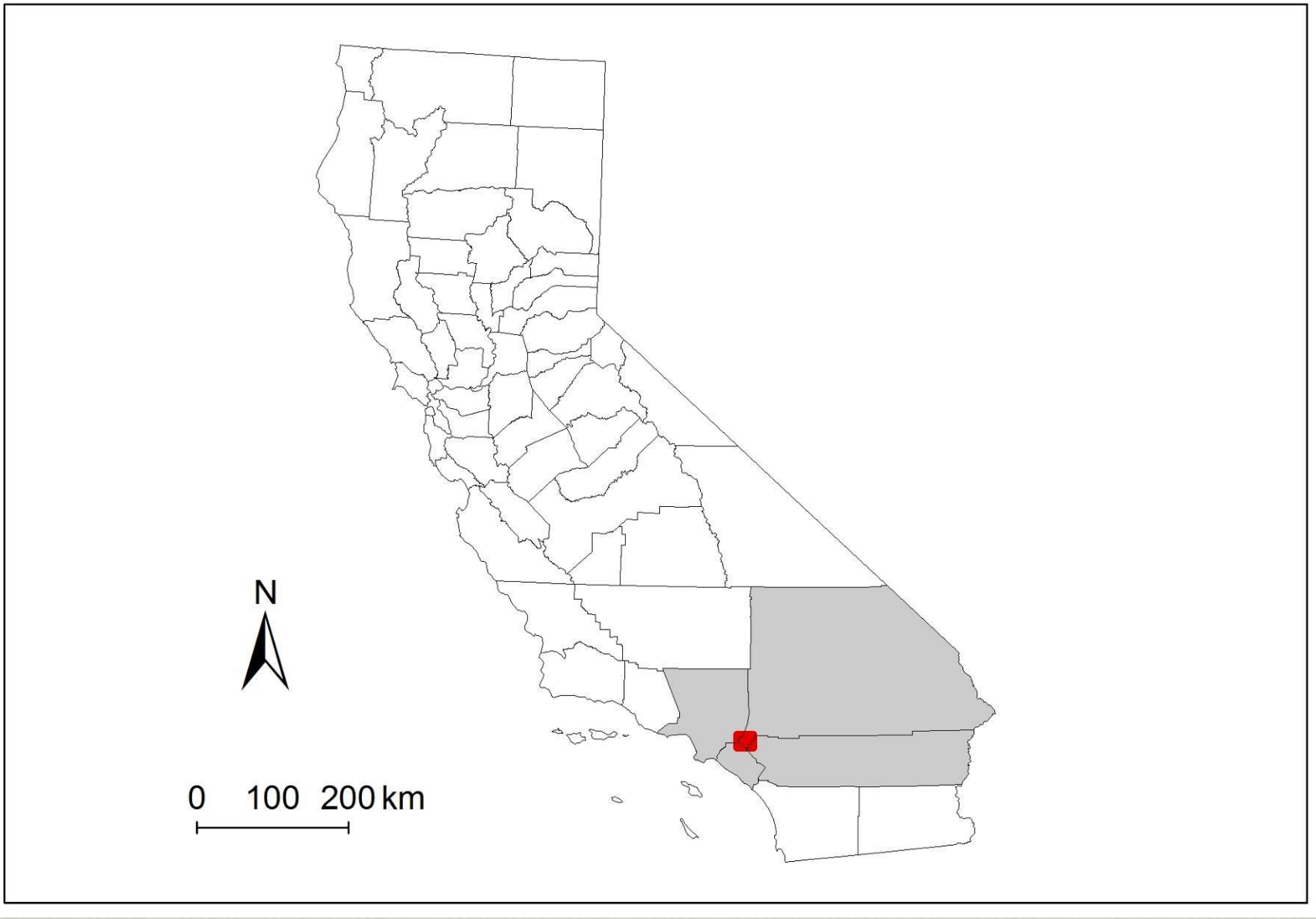
Healthy PLACES* Study
Chino, California

Natural intervention study designed to evaluate the effects of smart growth community design on family obesity risk (e.g. physical activity behavior)

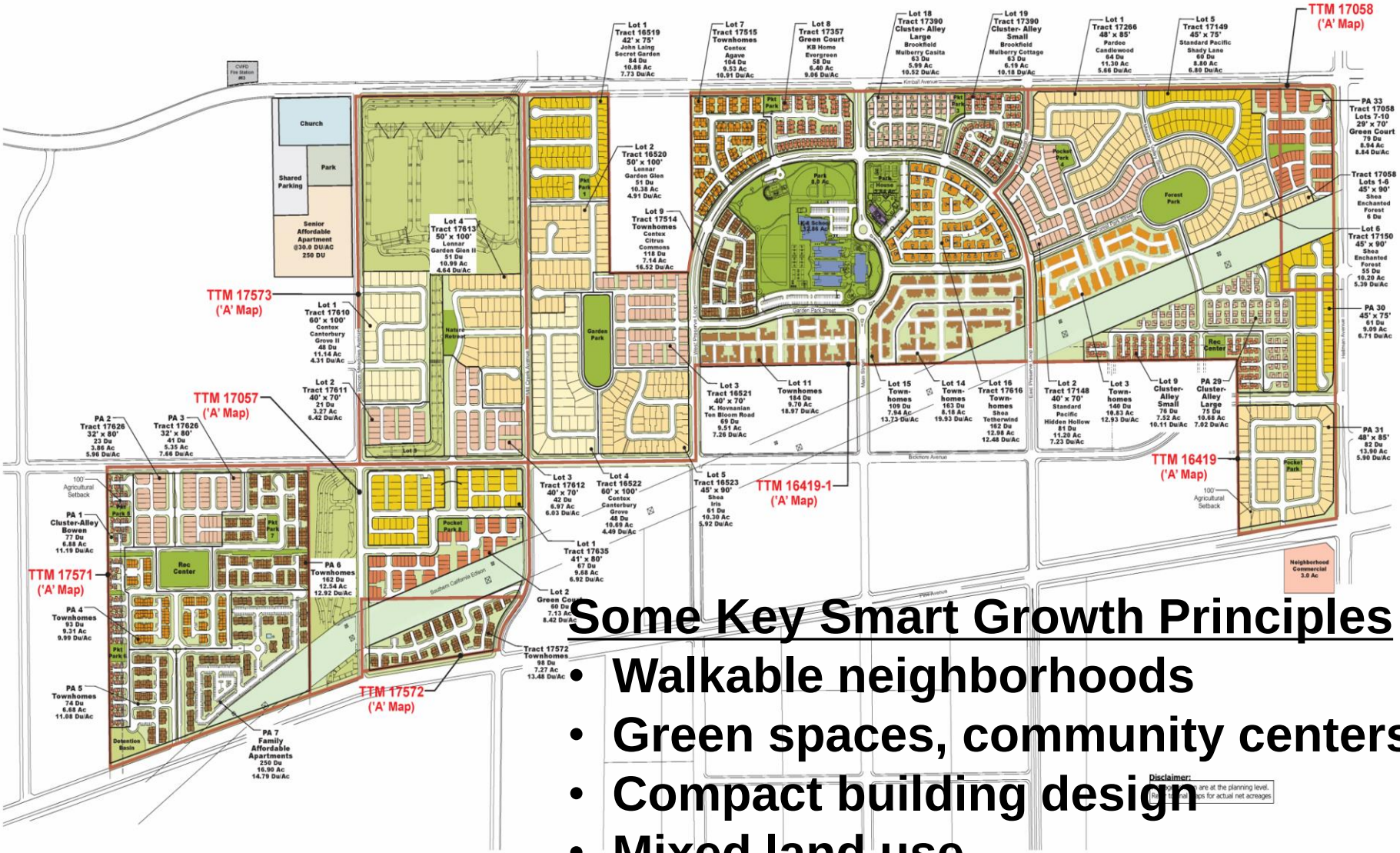
- Intervention group: smart growth residents **(~1/3**)
- Comparison group: community controls from nearby conventional communities and from random controls **(~2/3**)
- Anthropometric, accelerometer and GPS data
- Longitudinal: data collected annually for 4 years
- **386 families** at baseline for year 1 (1 parent and 1 child each)

**** P**romoting **L**ivable **A**ctive **C**ommunity **E**nvironment**S***

Healthy PLACES Study Area
Chino, California



The Preserve Community Plan



Some Key Smart Growth Principles

- Walkable neighborhoods
- Green spaces, community centers
- Compact building design
- Mixed land use

Current Study

- **Is neighborhood greenness exposure associated with heightened physical activity in children?**

- **If so, is the association stronger for children residing in a smart growth community?**

Space-Time-Activity Data Collection

GPS and Accelerometer (ACC) Monitoring Devices

GPS Logger GlobalSat BT 335

- Date & Time, Location
- (Latitude, Longitude), Speed

Accelerometer ActiGraph GT2M

- Date & Time
- Activity Counts (index for activity)

GPS-ACC collected every 30 seconds for 7 days (except when bathing, swimming, or sleeping)

Scope of Analysis:
Neighborhood Activity
Outside of Home & Non-School Hours

Neighborhood

500 m buffer

Home Excluded

30m buffer

Motorized Excluded

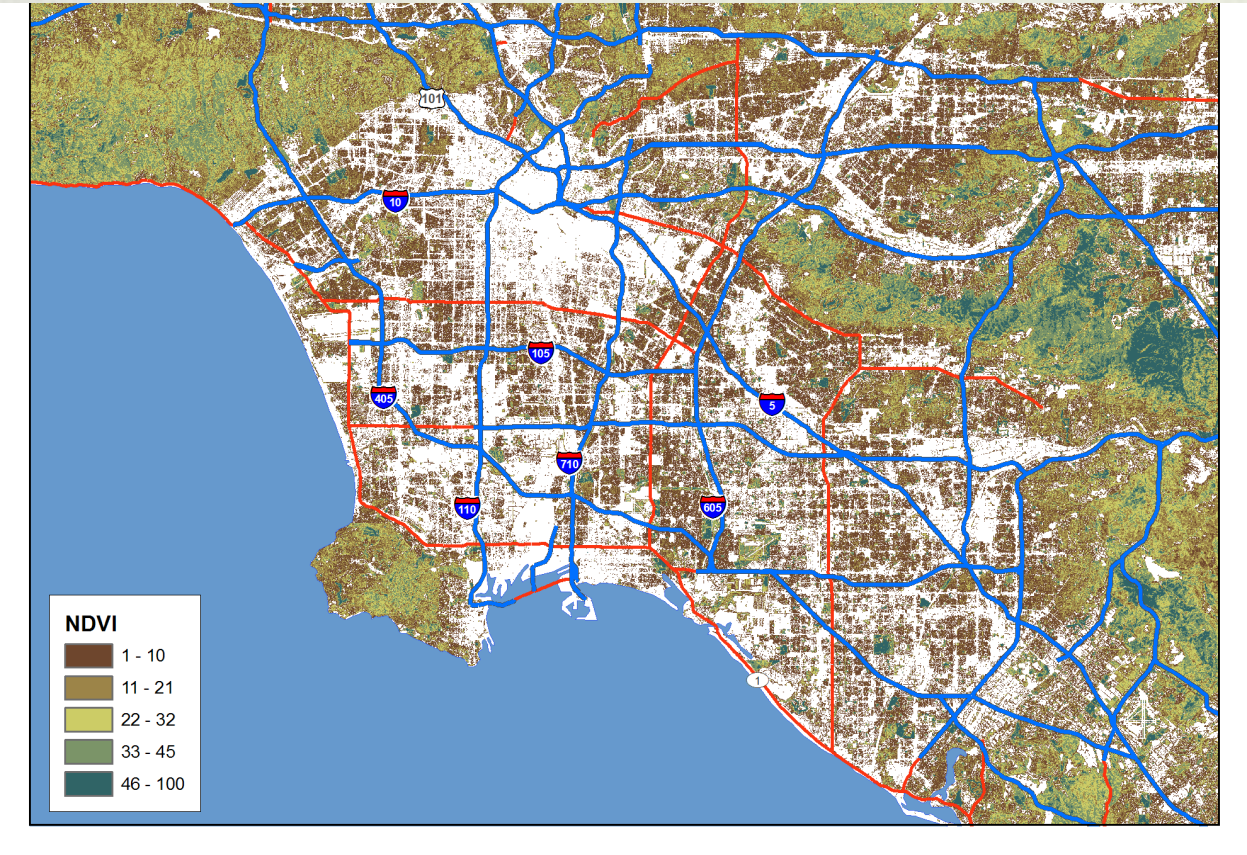
>32 kph/20mph

Excluded school hours (Aug 31-Jun 10, 9am-2pm)

Remote Sensed Indicator of Vegetation

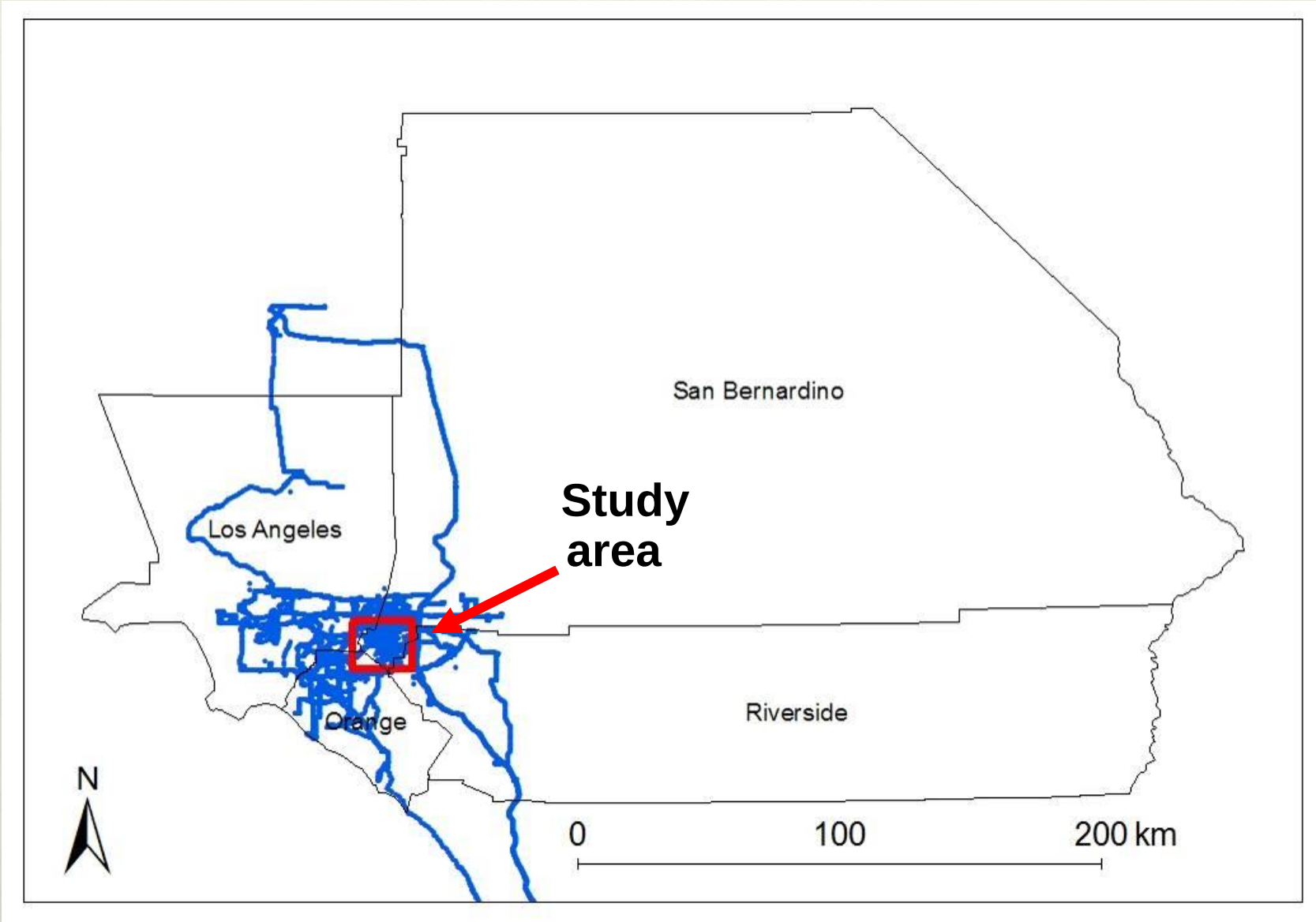
Normalized Difference Vegetation Index

= (NIR –RED) / (NIR +RED)

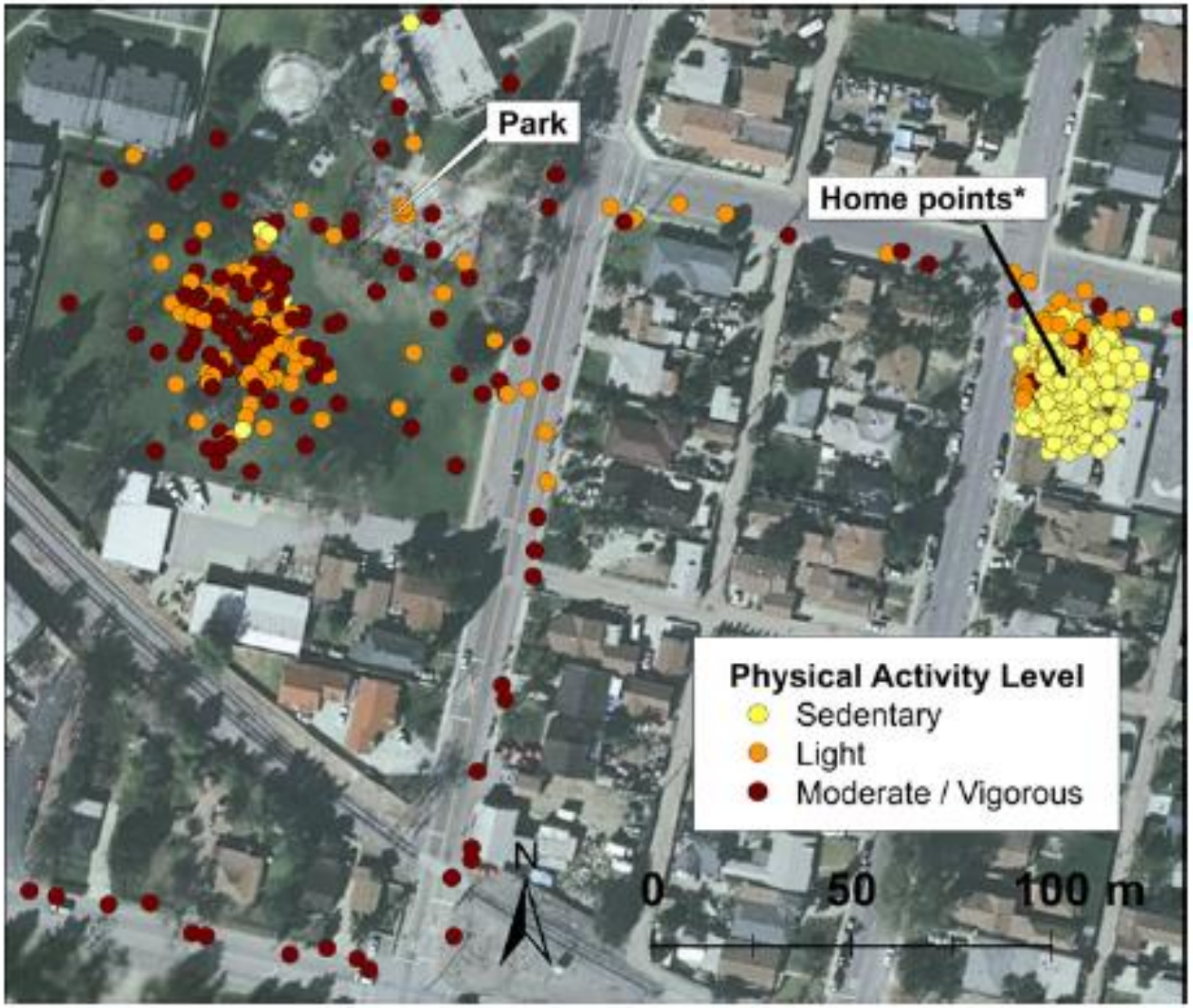


Assigned NDVI values to 30-second epochs in GIS

GPS Tracks for Sub-sample of Participants



Activity Pathway for 1 Child



Momentary Greenness Exposure and the Likelihood of MVPA
Logistic Regression with 142,552 30-second epochs from 208 subjects

	Definition	OR (95% CI)	P-value
Response Variable	0: Sedentary/light		
MVPA	1: Moderate/vigorous		
Covariates	Normalized difference		
NDVI[a]	vegetation index	**1.34** (1.30, 1.38)	**< 0.001**
Community Design Group	0: Conventional 1: Smart growth	1.26 (0.82, 1.92)	0.29
NDVI*Community	Interaction	**1.044** (1.001, 1.089)	**0.04**

Conclusions

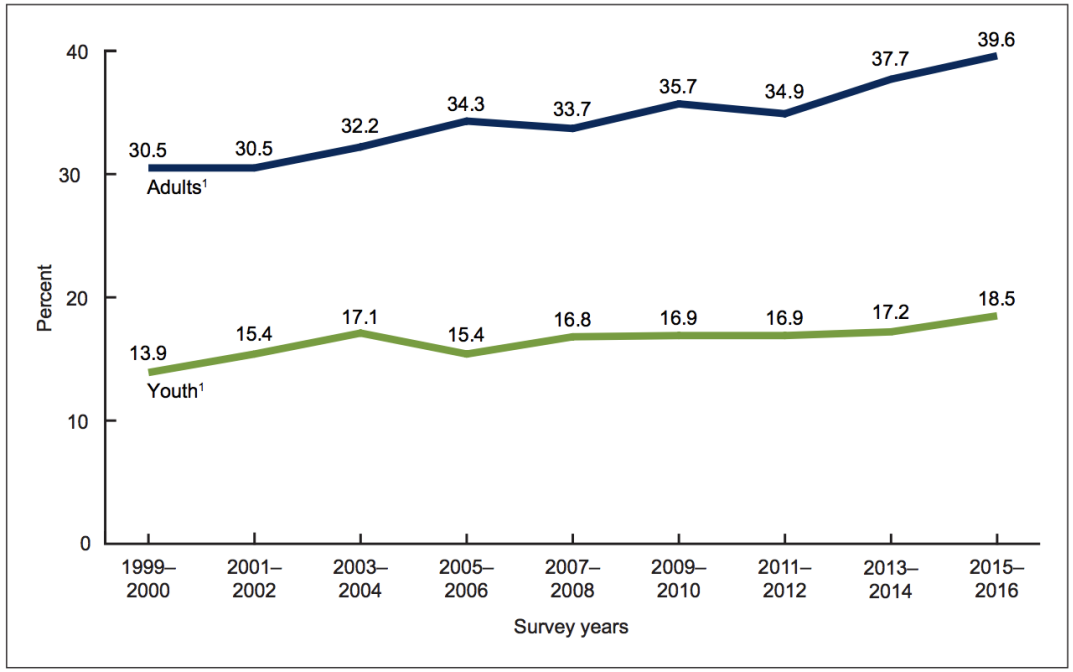
- Results indicate greenness was positively associated with children's momentary physical activity
- Although these results suggested modest effect sizes, the health impacts could be cumulatively substantial at the population-level
- Findings also suggest the greenness-physical activity association was stronger for residents from the smart growth community compared to conventional communities
- Both green space and community design important for physical activity

Access to Parks/ Programming and Obesity Development in Children

Jennifer Wolch, Michael Jerrett and colleagues

Obesity Continues to be a Serious Problem

Figure 5. Trends in obesity prevalence among adults aged 20 and over (age adjusted) and youth aged 2–19 years: United States, 1999–2000 through 2015–2016



[1]Significant increasing linear trend from 1999–2000 through 2015–2016.
NOTES: All estimates for adults are age adjusted by the direct method to the 2000 U.S. census population using the age groups 20–39, 40–59, and 60 and over. Access data table for Figure 5 at: https://www.cdc.gov/nchs/data/databriefs/db288_table.pdf#5.
SOURCE: NCHS, National Health and Nutrition Examination Survey, 1999–2016.

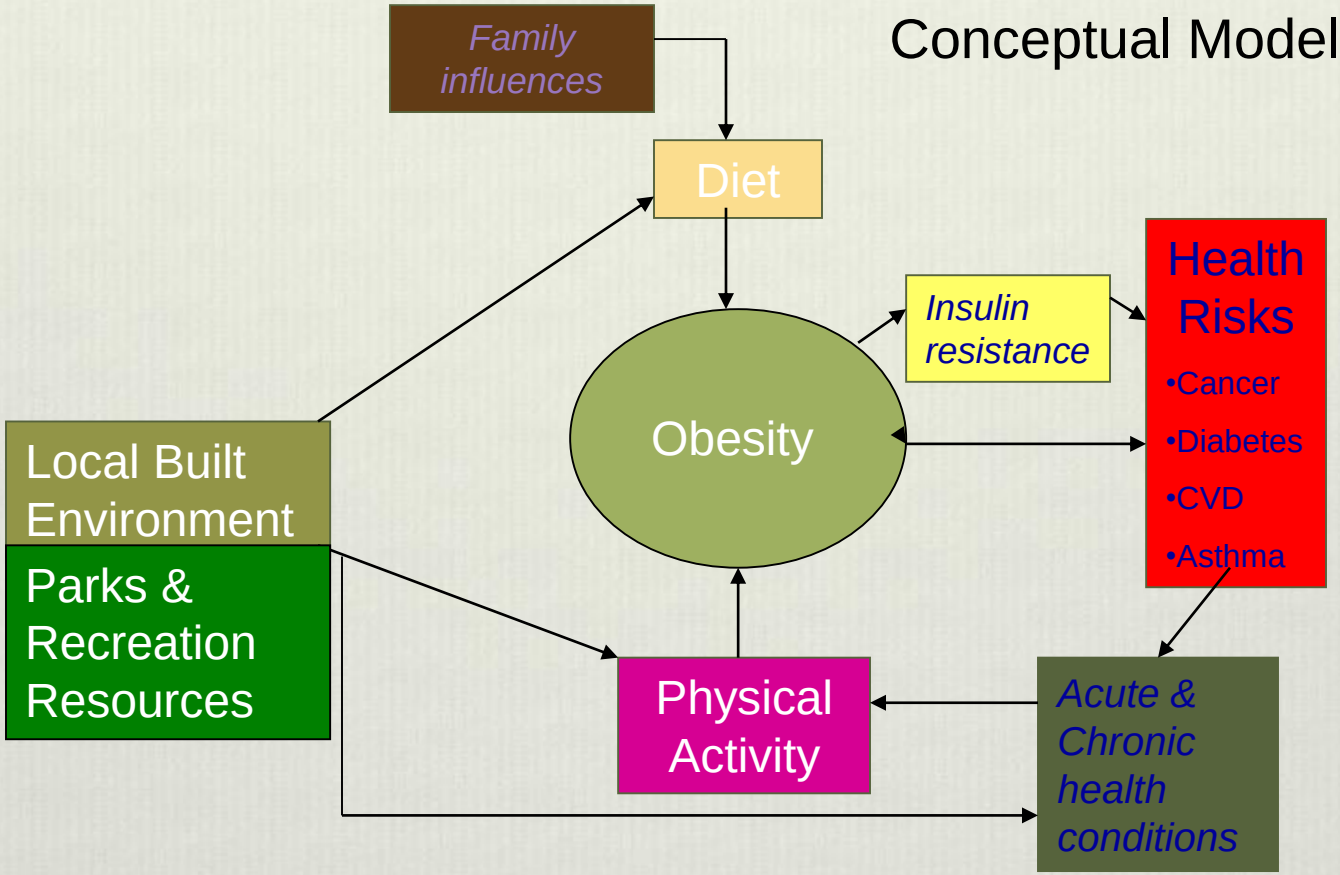
Source: Stateofobesity.org

Research Aim

- To assess the association between parks/recreational programming access and the longitudinal development of measured BMI (kg/m^2) in children aged 10-18 years

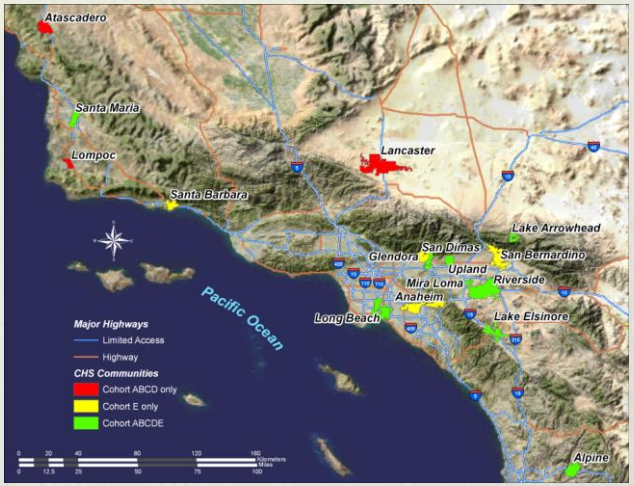
- Children's Health Study (CHS) offers longitudinal sample with objectively measured BMI data

Conceptual Model

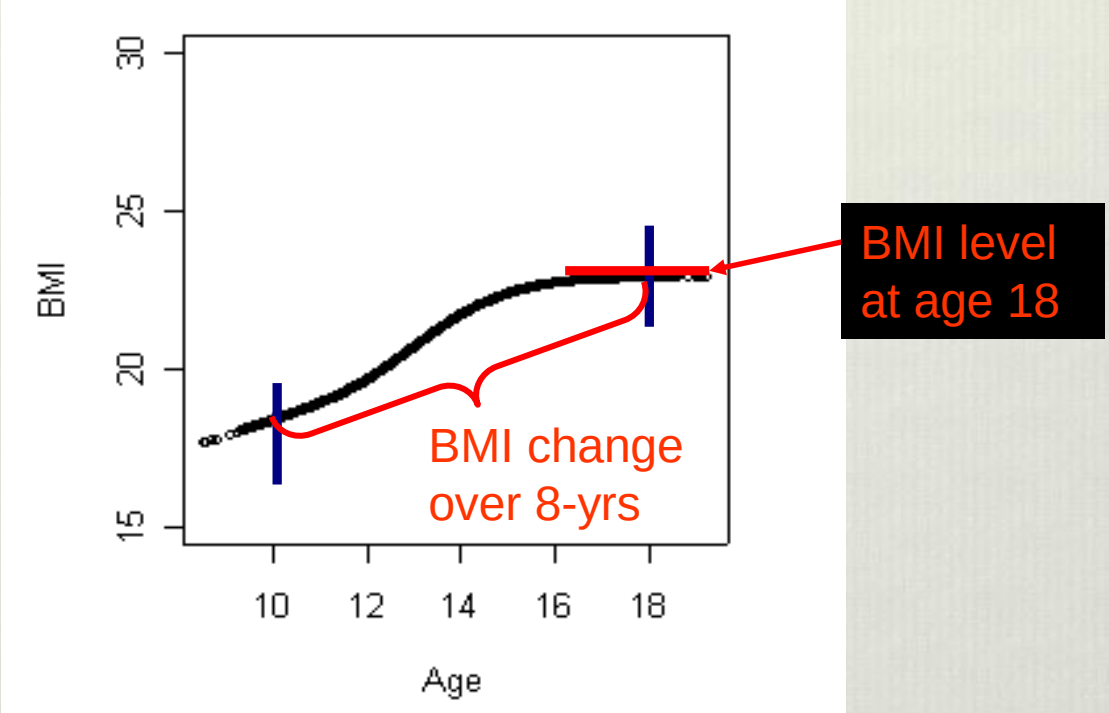


Data and Methods

- 11,797 CHS children
  - Up to 8 years of follow up
  - Building on $50+ million prior investment
  - 12 Southern California communities
  - BMI measured yearly by trained staff
- Geospatial data
  - Land use
  - Transportation
  - Business locations
  - Public facilities/programs
  - Green cover
  - Air pollution
- Use of flexible growth curve multilevel modeling



Models Focus on *Attained BMI at Age 18*

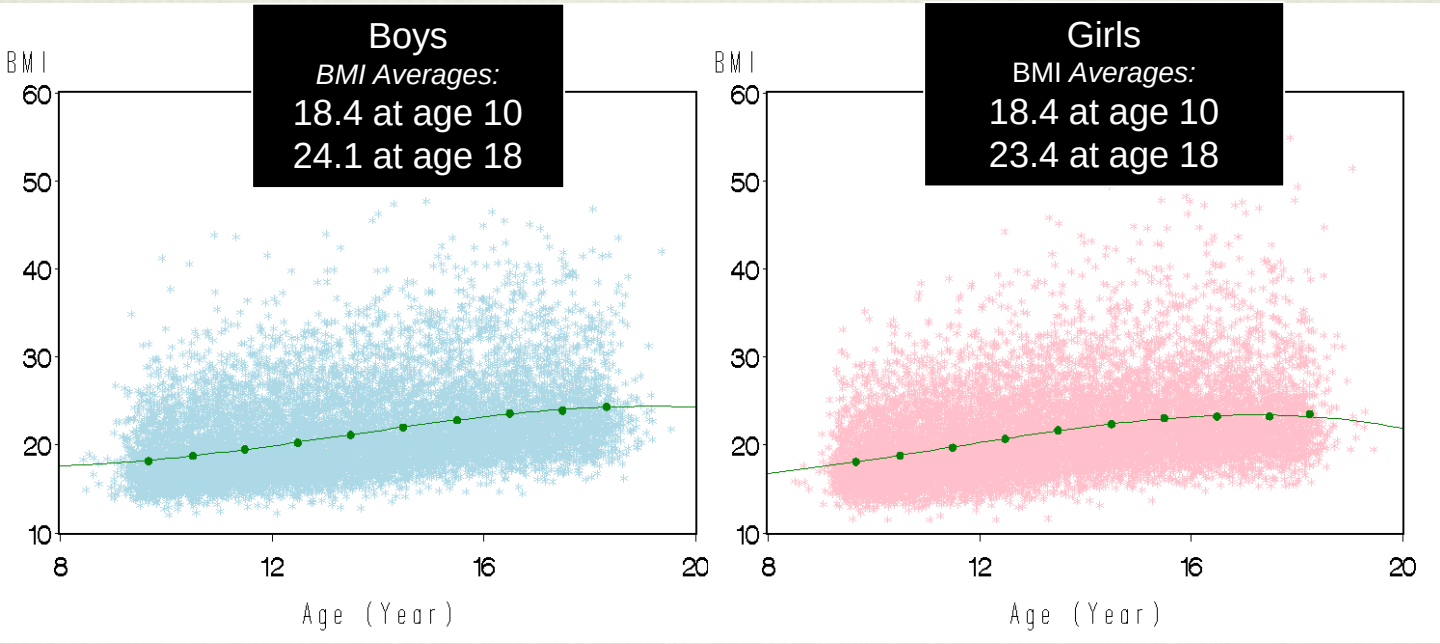


Characteristics of Analytic Cohort Age 10-18

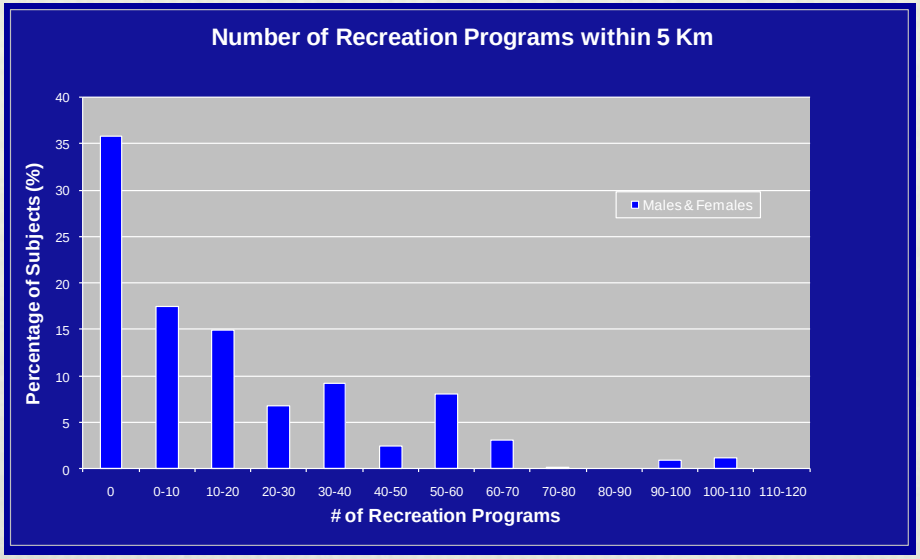
Cohort (year, # of subjects)	Prevalence Rate (%) of overweight (BMI ≥ 85th %ile)				
	All	Ethnicity			
		Non-Hispanic White	Hispanic	African American	Asian
(1993: 2192)	25.3	21.6	36.0	20.2	15.9
(1996: 2081)	27.5	24.0	34.5	31.0	21.6

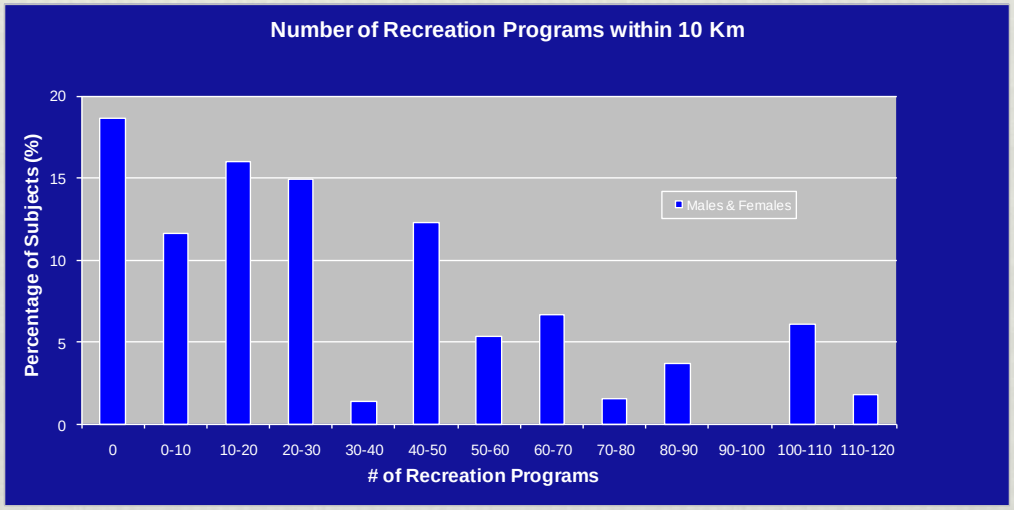
Analytic Cohort N = 3318 with 8 years of follow up from ages 10-18

BMI Growth Over 8 Years



Access to Recreation Programs

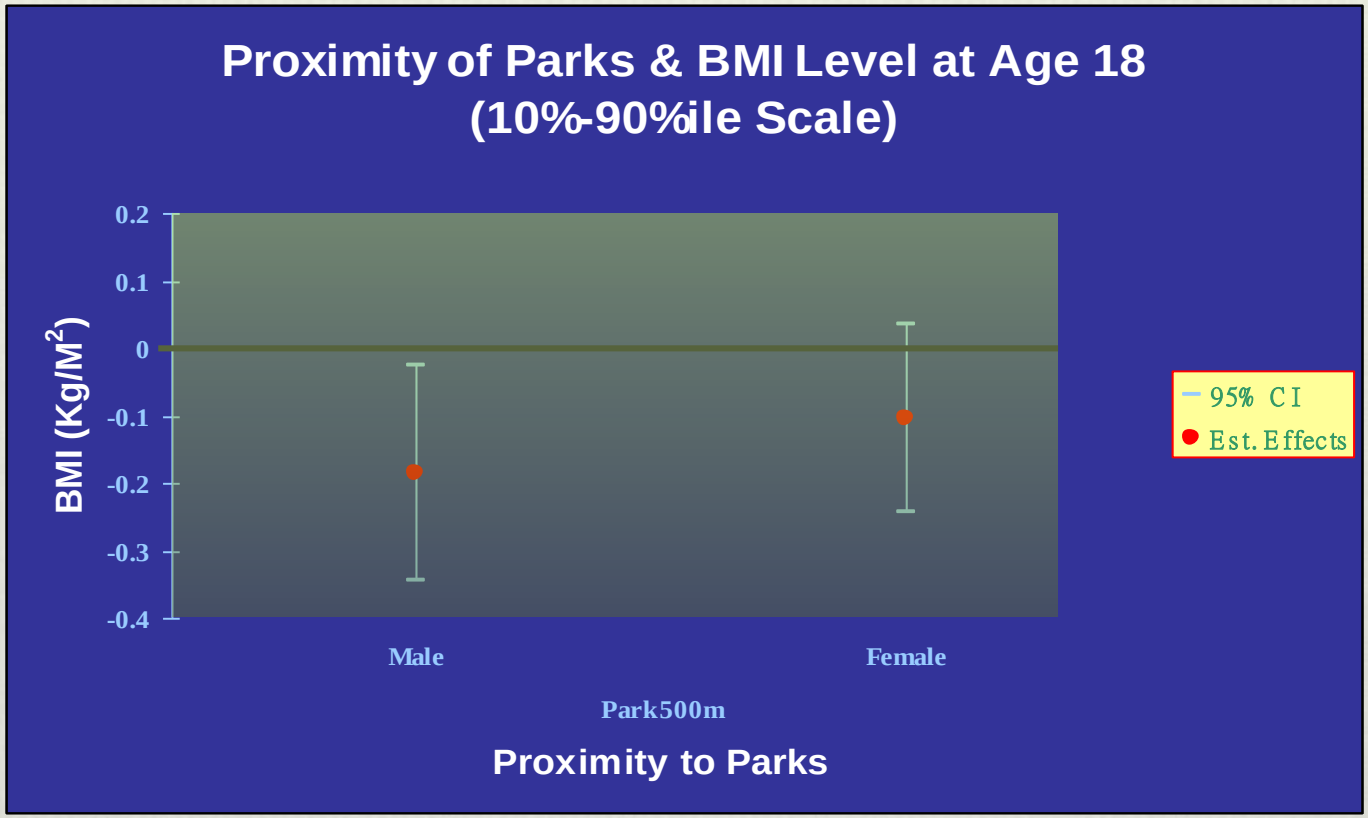




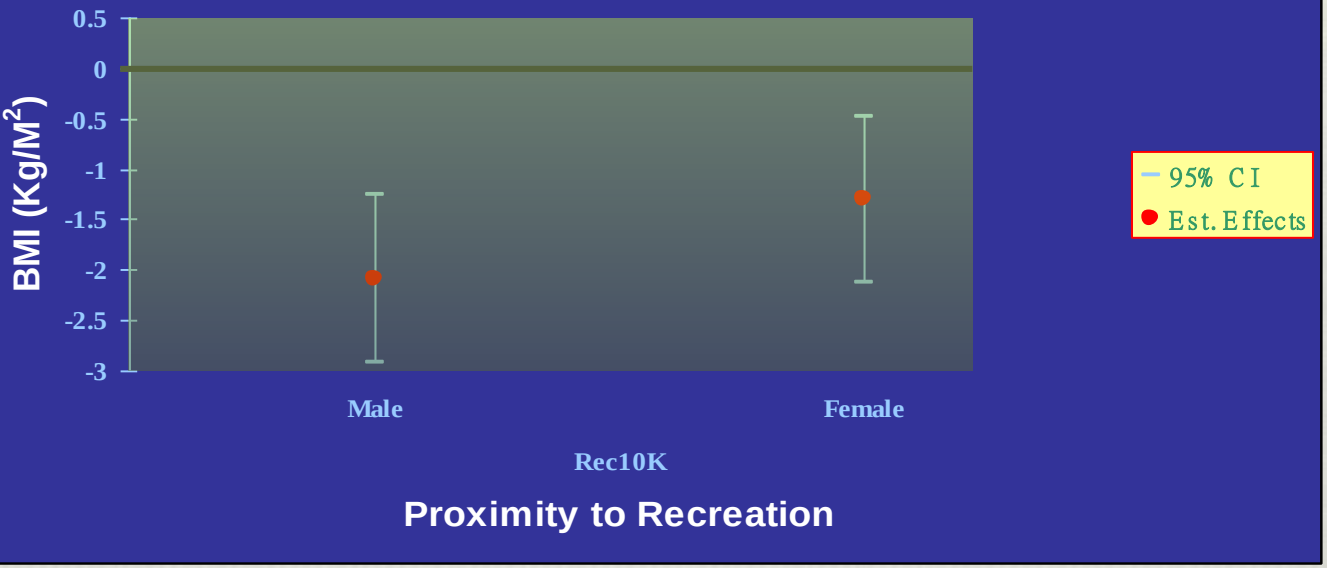
Model Results

(8-year Growth Curves, Age Centered at 18, with adjustments for ethnicity, town, gender, cohort, and park/recreation specific confounders)

Variable of Interest	Effect: Males (std)	Effect: Females (std)
Park space (km) within 500 meter buffer	-0.012*** (0.005)	-0.007* (0.005)
Recreation programs within 5 km buffer	-0.015*** (0.004)	-0.008*** (0.004)
Recreation programs within 10 km buffer	-0.025*** (0.005)	-0.016*** (0.005)


Proximity of Parks & BMI Level at Age 18
(10%-90%ile Scale)
BMI (Kg/M2)
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Male
Female
Park500m
Proximity to Parks
95% CI
Est. Effects

Proximity of Recreation & BMI Level at Age 18 (10%-90%ile Scale)



Results Summary

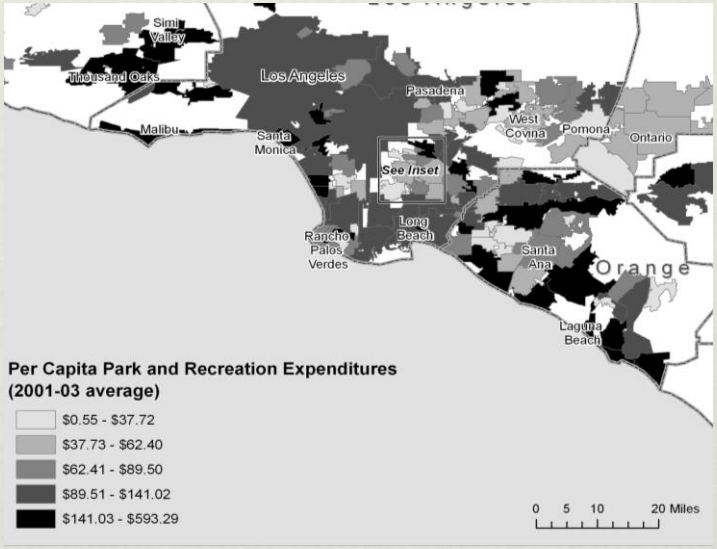
- Park space within 500 m of child's home inversely associated with BMI at age 18
- Public recreational programs ≤10 km of child's home also protective for obesity **with large effects**
- Many children have poor access to public recreational programs
  - *Almost 20% have no access within 10 km*
  - *36% have no access within 5 km*

Interpretation of Findings for Recreational Programs and BMI

- If all children had comparable access to recreational programs:
  - ***Boys:*** *11.26% move from overweight to normal; 3% from obese to overweight*
  - ***Girls:*** *8.5% move from overweight to normal; almost 3% from obese to overweight*

Connections to Active Living Interventions

- Increase park space and recreational programming near poor and minority neighborhoods with high densities of children likely to reduce obesity



GREEN SPACE AND AIR POLLUTION

Measurements	100-m buffer: Regression coefficient (95% CI)	100-m buffer: *p*-Value
Personal (adjusted)[b]		
$PM_{2.5}$	–5.9 (–10.0, –1.8)	< 0.01
NO_x	–5.1 (–18.6, 8.4)	0.45
Home-indoor[c]		
$PM_{2.5}$	–6.1 (–10.6, –1.6)	< 0.01
NO_x	–9.5 (–24.4, 5.3)	0.20
Home-outdoor[d]		
$PM_{2.5}$	–4.4 (–9.5, 0.7)	0.08
NO_x	–5.8 (–17.6, 6.0)	0.33

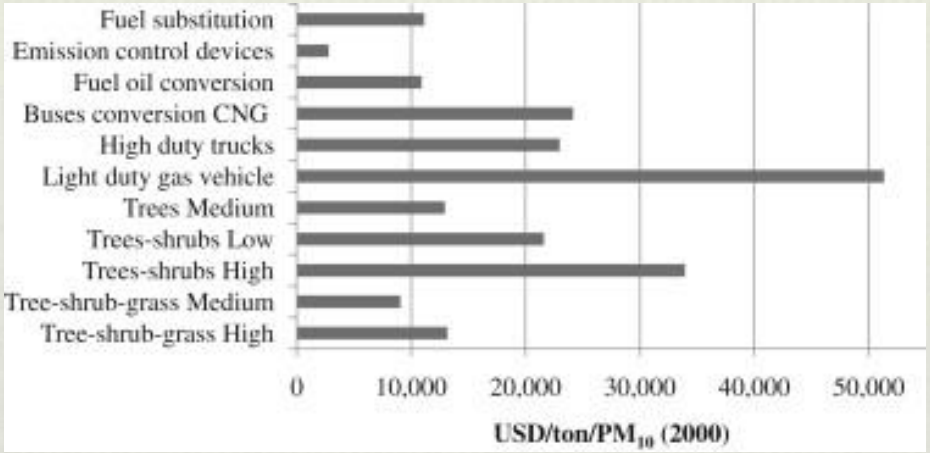
Regression coefficients for interquartile range increase NDVI for 100 m buffer

Dadvand et al 2012

Reduction in Air Pollution in the United States

- Nationally trees remove 17.6 million tons of air pollution per year
- Avoided mortality is 850 deaths
- Avoided acute respiratory infections avoided 670,000
- Monetary value is about $6.8 billion per year (Novak et al. 2014)

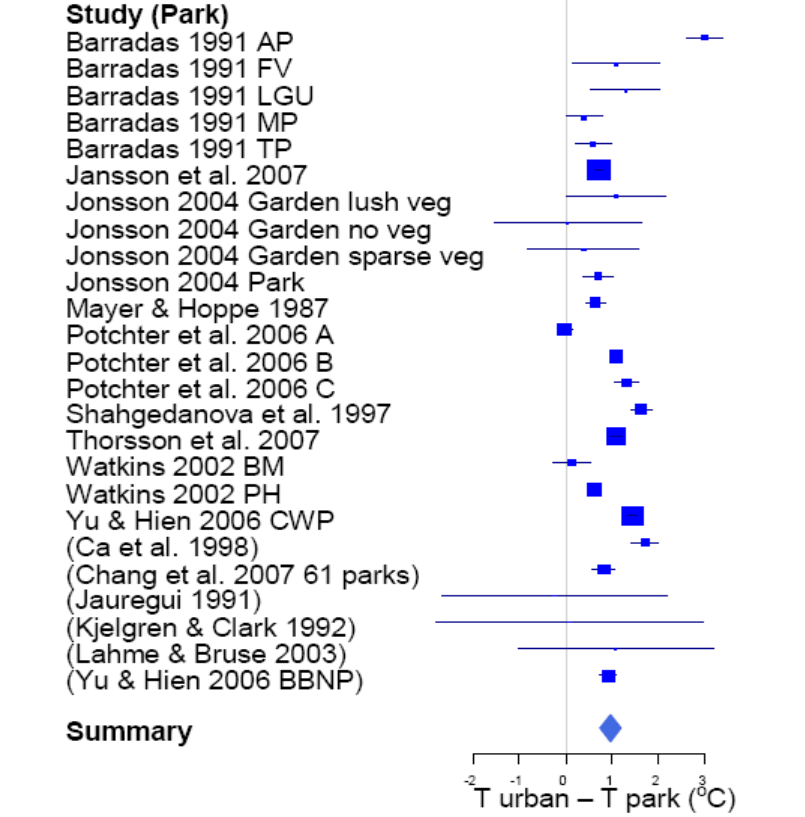
AIR POLLUTION (PM_{10}) MITIGATION AND GREEN SPACES



Cost-Effectiveness in US Dollars (USD) of using trees, shrubs and grassy areas to remove particulate matter less than 10 microns in diameter (PM 10) pollution in Santiago, Chile ...

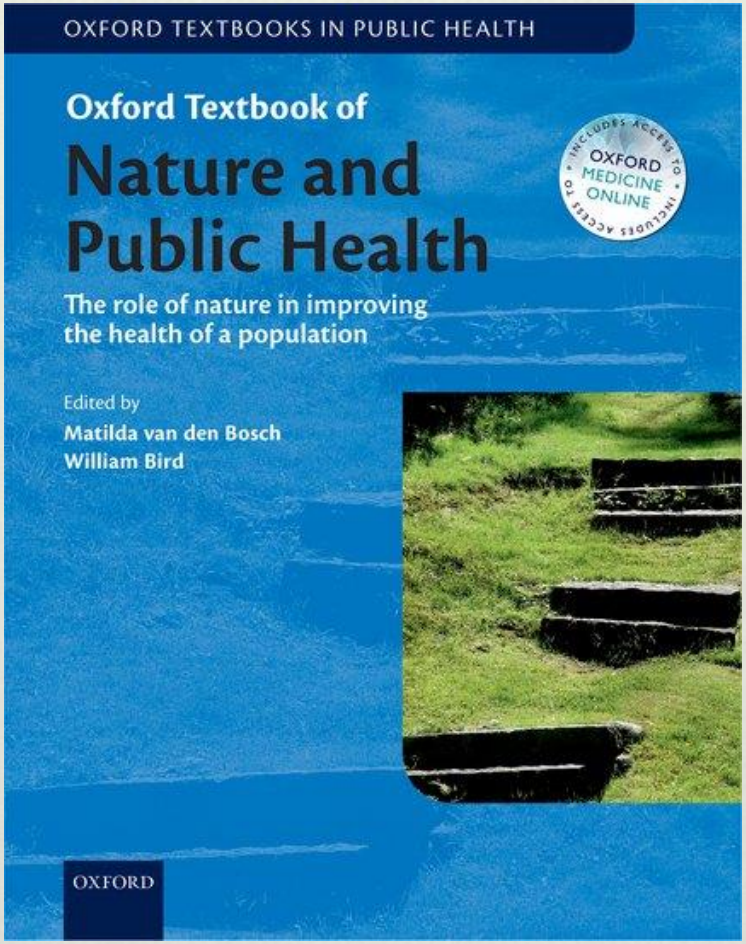
Escobedo et al., 2011. Environmental Pollution, Volume 159, Issues 8–9, 2011, 2078 - 2087

GREEN SPACE AND TEMPERATURE



Bowler et al 2010


EVA M. SELHUB MD ALAN C. LOGAN
YOUR BRAIN ON NATURE
THE SCIENCE OF NATURE'S INFLUENCE ON YOUR HEALTH, HAPPINESS, AND
GREEN EXERCISE
LINKING NATURE, HEALTH AND WELL-BEING
Copyrighted Material
the NATURE FIX
THE JAPANESE ART AND SCIENCE OF SHINRIN-YOKU
FOREST BATHING
HOW TREES CAN HELP YOU FIND HEALTH AND HAPPINESS
DR. QING LI
CHAIRMAN OF THE JAPANESE SOCIETY FOR FOREST MEDICINE
WILLIAMS
OXFORD TEXTBOOKS IN PUBLIC HEALTH
Oxford Textbook of Nature and Public Health
The role of nature in improving the health of a population
Edited by Matilda van den Bosch William Bird
OXFORD
RICHARD LOUV
Andy McGeeney
THE POWER OF PARKS
A YEARLONG CELEBRATION OF OUR COMMON GROUND
Vitamin N
500 Ways to Enrich the Happiness of Your Family &
*and Combat Nature-Deficit
RICHARD LOUV
author of Last Child in the Woods: Saving Our Children
WITH 100 ACTIV
MANUAL FOR
LTH PROFESSIONALS
FOREWORD BY LINDSAY ROYAN
Andy McGeeney
Vultures
MORE VITAL THAN VILE
NATIONAL GEOGRAPHIC
THE POWER OF PARKS
A YEARLONG CELEBRATION OF OUR COMMON GROUND



https://global.oup.com/academic/product/oxford-textbook-of-nature-and-public-health-9780198725916?cc=se&lang=en&

How to promote health equity by greening cities?

1. Green cover and forest expansion
2. Parks and open space expansion
3. Joint use agreements with Schools
4. Access improvements
5. Stream daylighting
6. Streetscape design
7. Use of 'remnant' urban land such as alleys
8. Brownfield remediation
9. Shared streets
10. Backyards – increasing species diversity and native plants

Adapted from Dr. J. Wolch pers. comm.

Broader Conclusions

- Green space supply and quality lower in social deprived areas of LA and in many parts of the world
- Given the many health benefits of contact with nature, unequal distributions will likely worsen health inequities
- Greater investment in disadvantaged areas will likely yield major health benefits
- Will require major multi-sector initiatives to green the city to promote health equity

Acknowledgements

- Drs. Matilda van den Bosch, Jennifer Wolch and Mark Nieuwenhuijsen and to Ms. Estela Almanza for sharing slides
- National Cancer Institute, National Institute of Environmental Health Sciences, Robert Wood Johnson Foundation
- Thank YOU for your time today!