TOYOTA

What's Driving All This Driving?

Progress, Challenges, Opportunities

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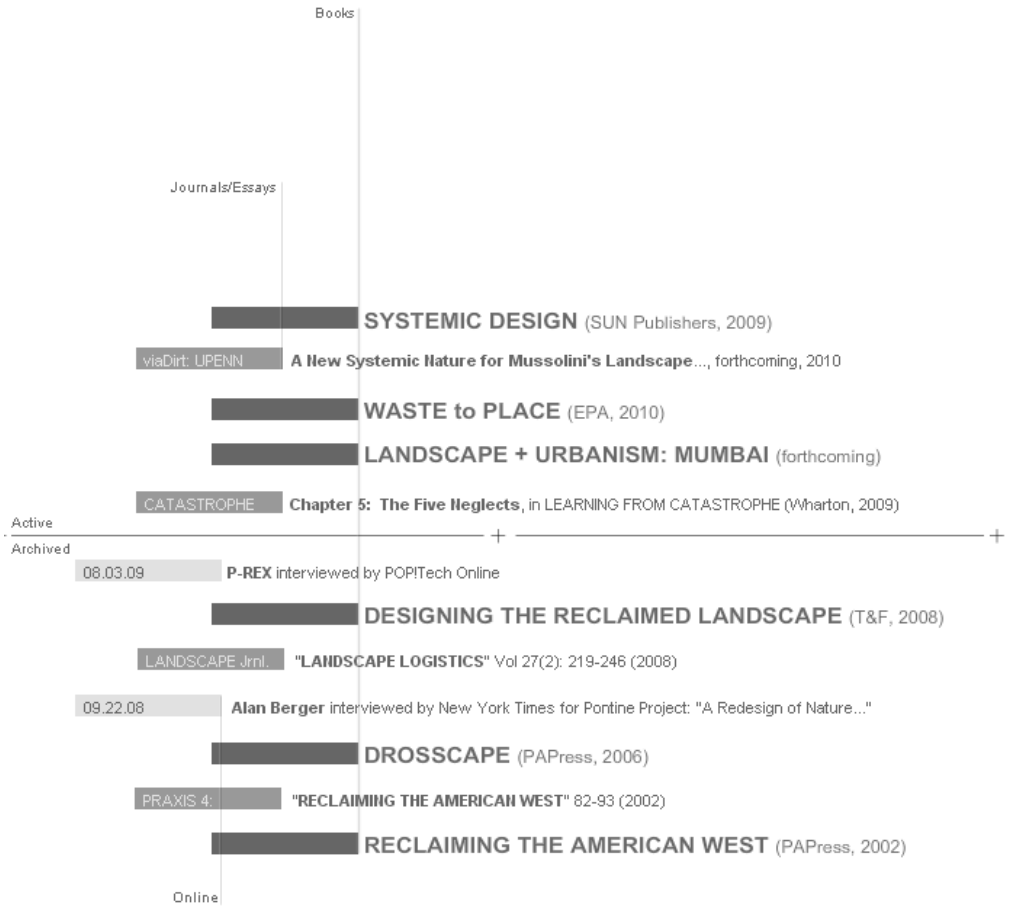
P-REX

http://www.theprex.net/

Alan Berger

Case Brown



Outline

- Technology
- Mobility Demand
- Housing
- Employment
- Mobility Trends

Sound Familiar?

Era of abundant fuel has ended for good

Romance with car ending

Middle-class returns to city, avoids cars

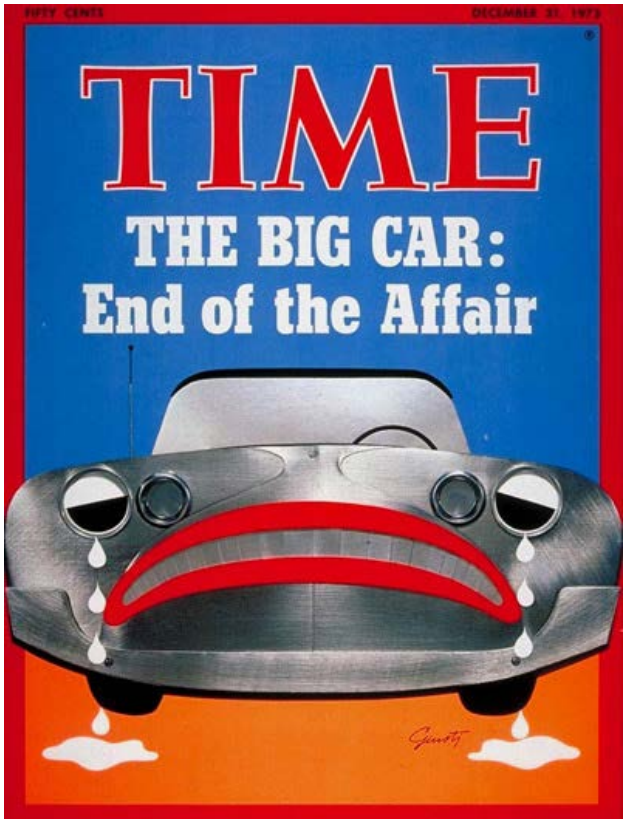
Public Transportation Revival

One occupant-per-car must end

Predictions: 1973

The Painful Change to Thinking Small, Time Magazine, Dec 31, 1973

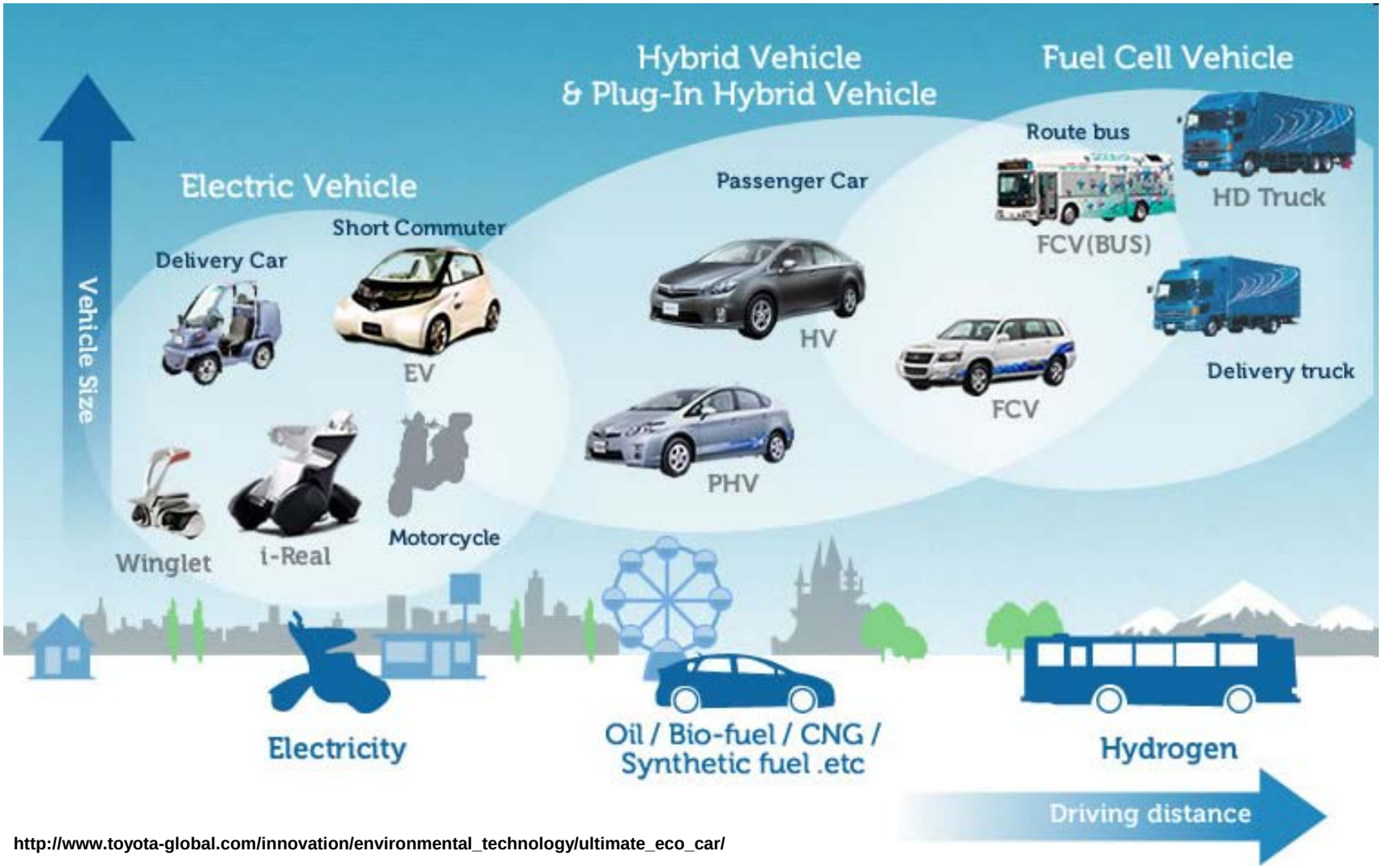
- *There have been multiplying signs that the long American romance with the big car may finally be ending.*
- *More likely, the heavy car will linger as a limited-purpose, special-use auto, but not again become the basic American vehicle*
- *Economists generally are agreed that the era of readily abundant fuel has ended for good.*
- *Public transportation will experience a revival*
- *Car pooling will have to increase…the one-occupant-per-car habit is simply too expensive to be continued.*
- *Socially, there could be a movement of middle-class whites back to the city, where they can get away from auto dependence.*



What have we learned since then? Is it enough?

Technology

Toyota's vision: The right vehicle, at the right place, at the right time



http://www.toyota-global.com/innovation/environmental_technology/ultimate_eco_car/

“Prediction is very hard, especially about the future”

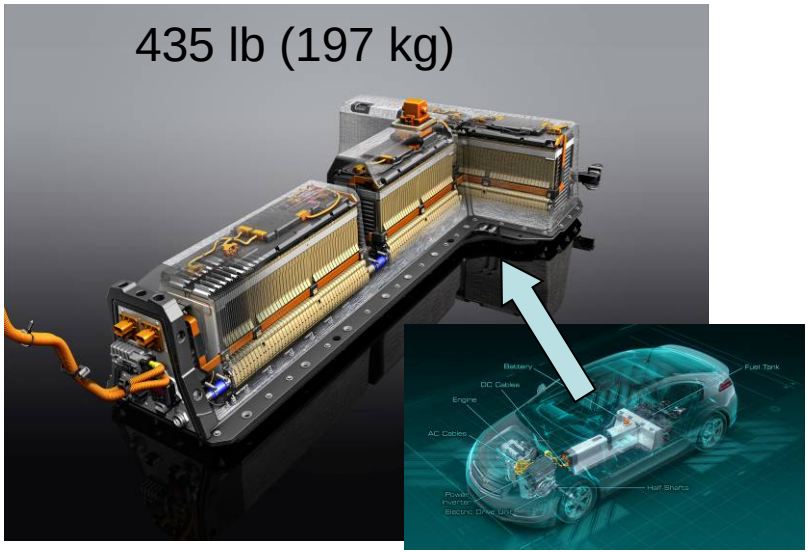
- Yogi Berra

Success of any sustainable vehicle strategy highly sensitive to future events.

- Well-to-wheels: Speed of grid “going green”: CCS, renewables, etc.
- Gas Price
- Battery improvement rate
- Future government policies/regulations

Batteries Have a Long Way to Go

Chevy Volt Battery



≈ 37 mi ≈

10-12 hr charge (L1)

3-4 hr charge (L2)

$3.50

6 lb (2.7 kg)

Compared to the same range of gas, the battery is

75 times heavier

1000 times more expensive

Assumes prices of $3.50/gal of gas and at least $250/kWh for the battery

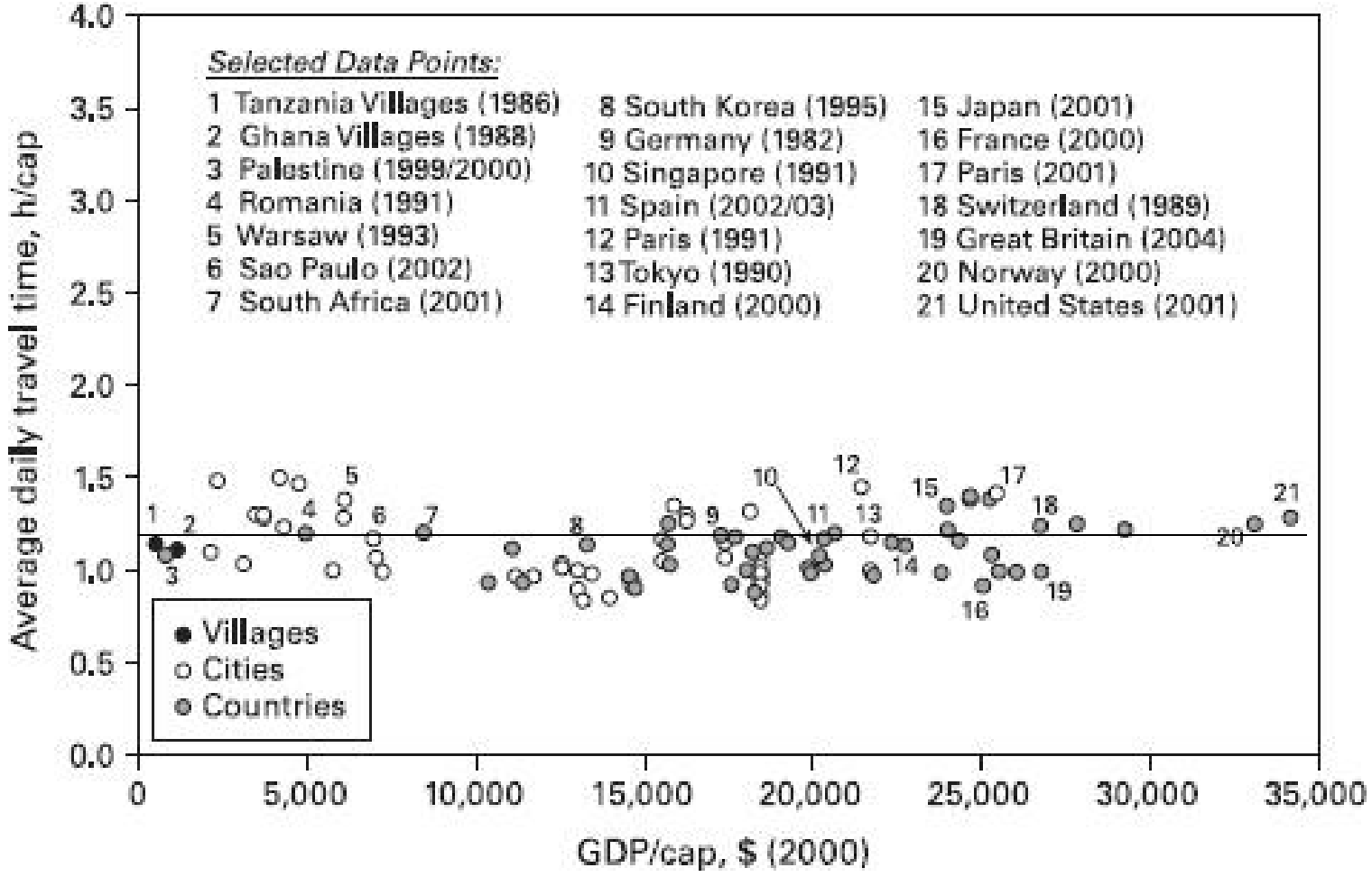
Cost drives adoption rates

- Which would you buy (in 2004)?
  - 2004 Corolla $13.5k 34 MPG
  - 2004 Prius $20.5k 46 MPG
- At time, criticism from both sides, i.e. industry observers (bad value trade-off) and environmentalists (not green enough).
- But, over 2M Prii sold, saved millions of tons CO_2

Prices are minimum MSRP, MPG is EPA Combined. 2004 Prius had 3.4 cu-ft more cargo room than 2004 Corolla

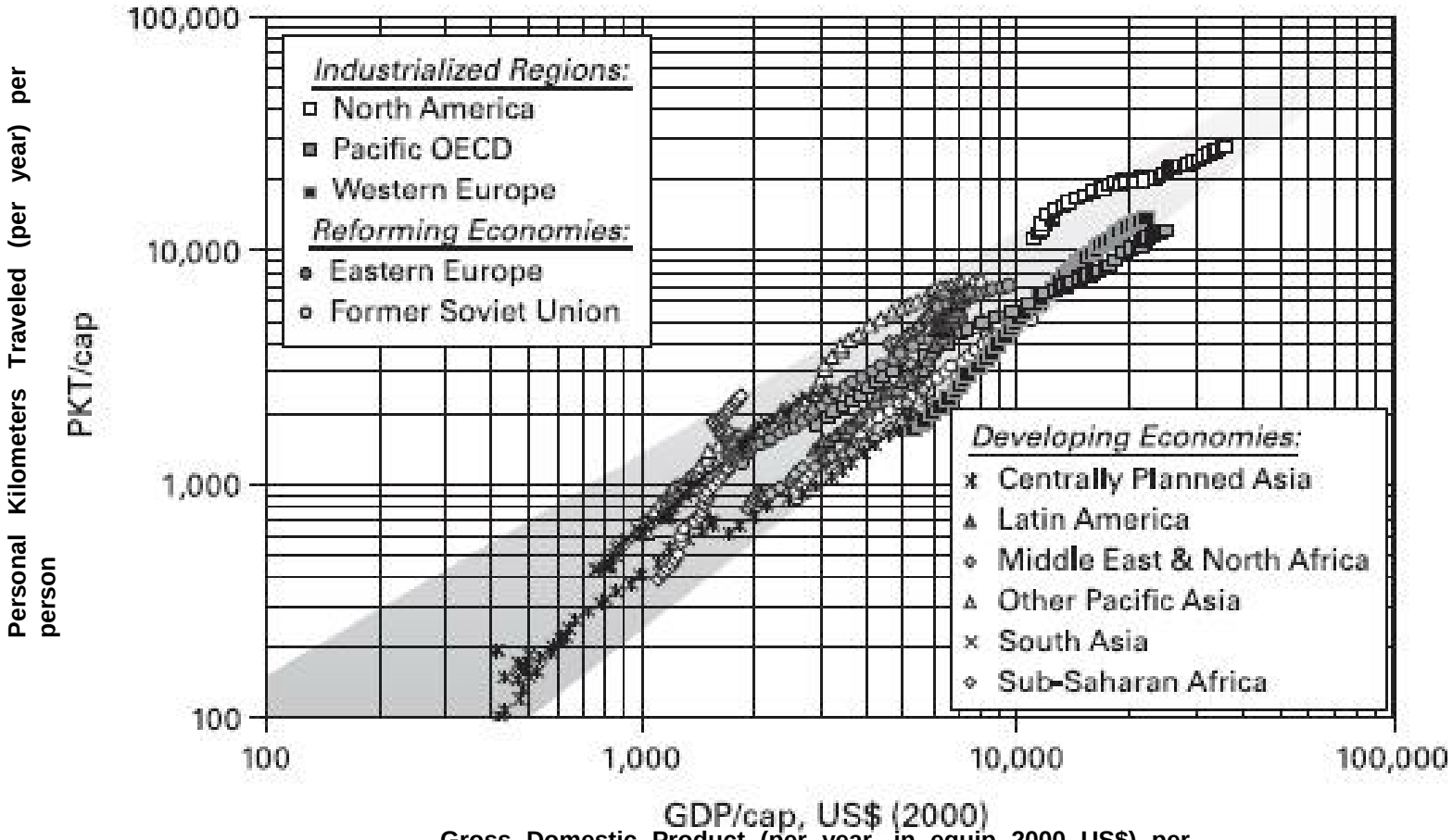
Mobility Demand

Across cultures and decades, people travel approx. 1.2 hrs/day



Average daily travel time in hours per person as a function of GDP per capita. Source: updated dataset of Schäfer, A., D.G. Victor, 2000. The Future Mobility of the World Population, *Transportation Research A,* 34(3): 171-205.

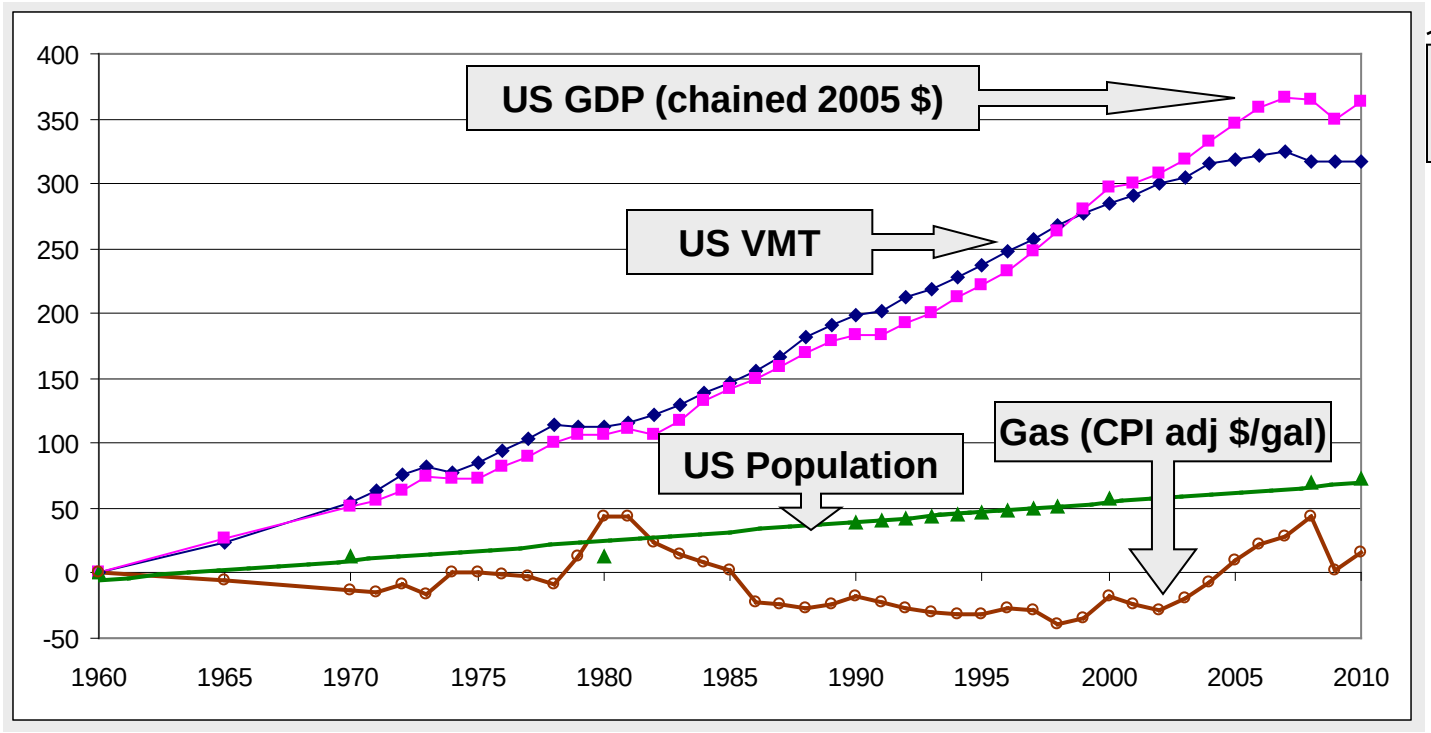
Historically, wealth and travel distances have increased nearly 1:1



Gross Domestic Product (per year, in equip 2000 US$) per person

Passenger kilometers traveled (PKT) per capita over per capita GDP (in purchasing power parity) for eleven world regions and the world between 1950 and 2005. Source: updated dataset of Schäfer, A., 1998. The Global Demand for Motorized Mobility,*Transportation Research A,* 32(6): 455-477.

Vehicle Miles Traveled vs. Economy



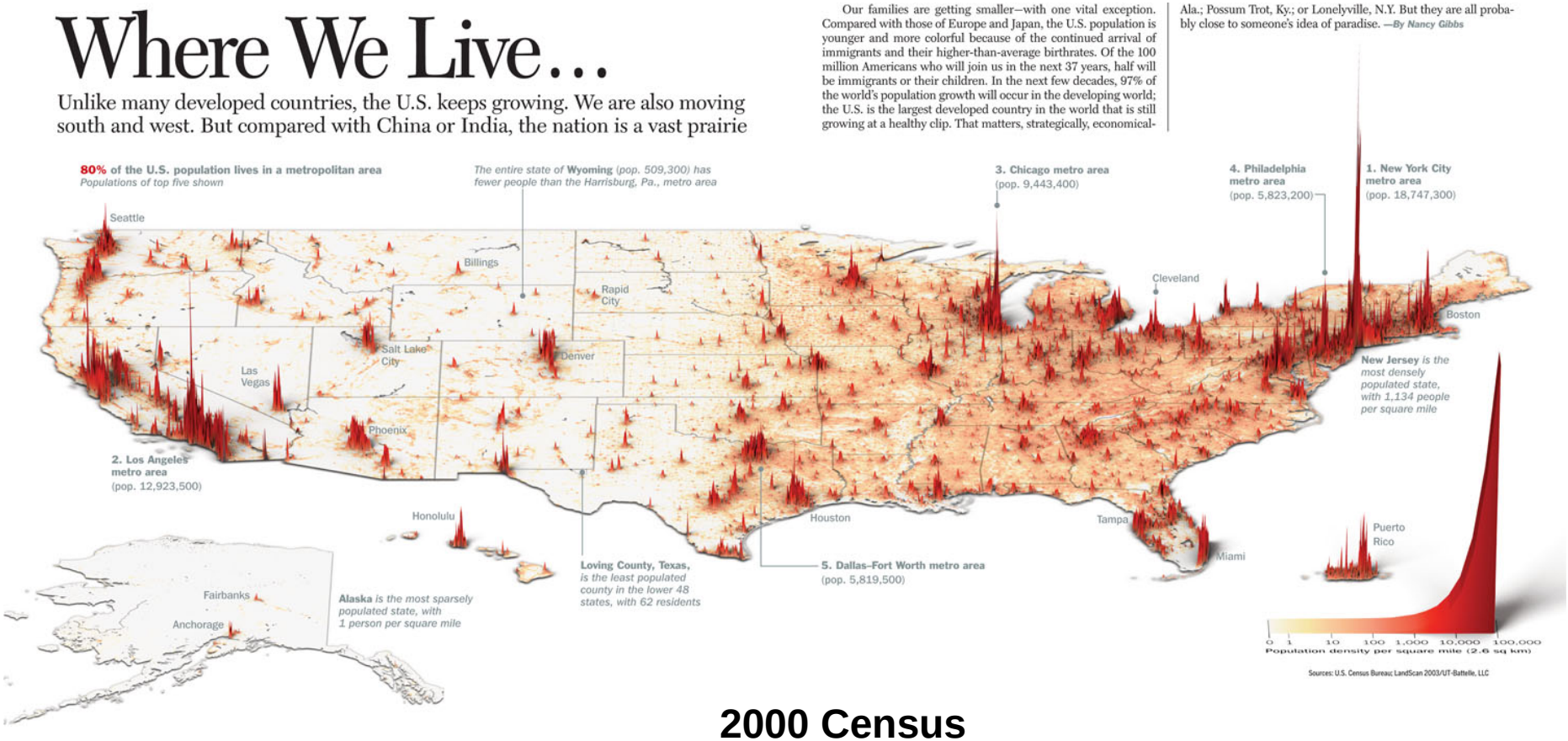
(sources: GDP: US Bureau of Economic Analysis, chained 2005 dollars; Vehicle Miles Traveled (VMT): "Highway Statistics 2009" Table VMT-421, FHWA; Population: US Census; Gas Price: "Short Term Energy Outlook" US Energy Information Administration, annual prices scaled by US Consumer Price Index (CPI) in 2008)

Fifty years of US Travel and Economic Trends. Note how closely the VMT and GDP are correlated.

My Observations

- These data suggest two things
  - Historically, more income equals more travel, regardless of any other factor (culture, geography, etc.) Trend is valid for US.
  - People do not want to spend more of their day "wasting time" with travel
  - People do not want to spend more money in order to further reduce travel time
- In other words, travel time seems to have an upper and lower bound

Housing



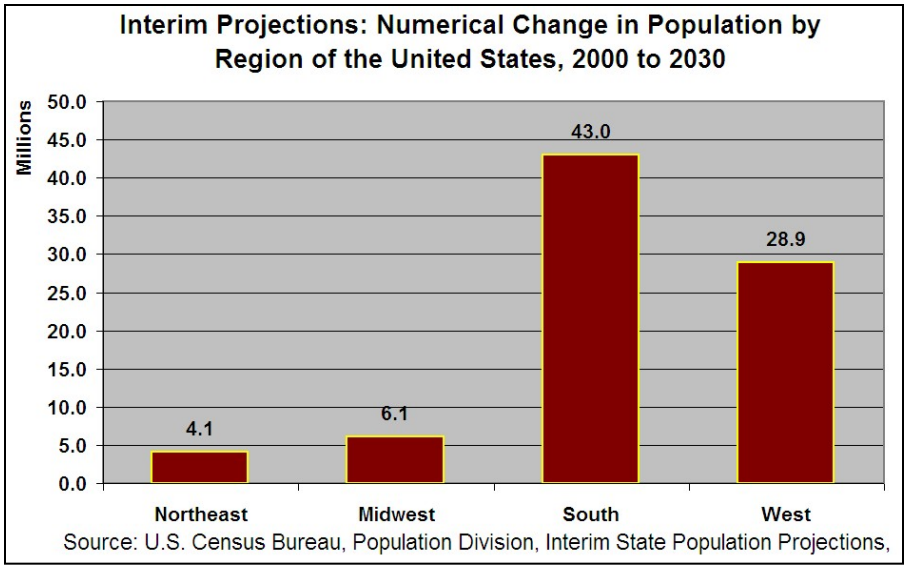
2000 Census

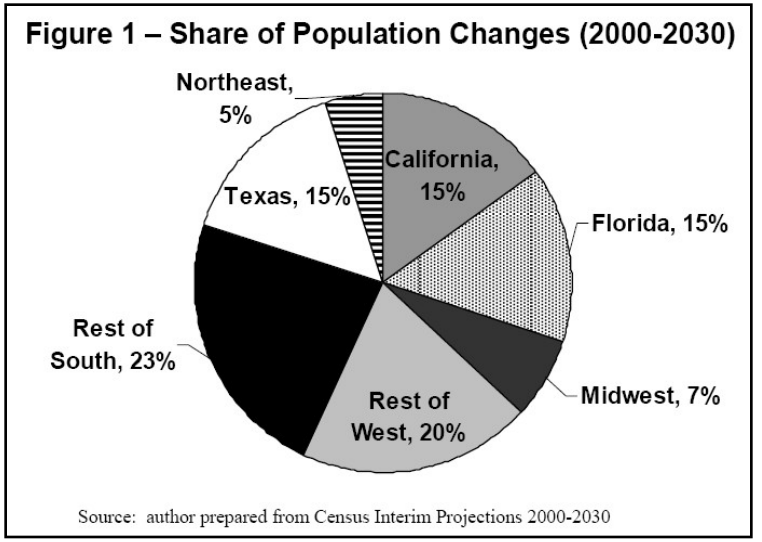
Joe Lertola,
This map of U.S. population density appeared in Time magazine Oct. 30, 2006 issue.
http://www.joelertola.com/grfx/population/pop.html

Moving South and West

Mean Center of United States Population
1790-2000

Moving South and West

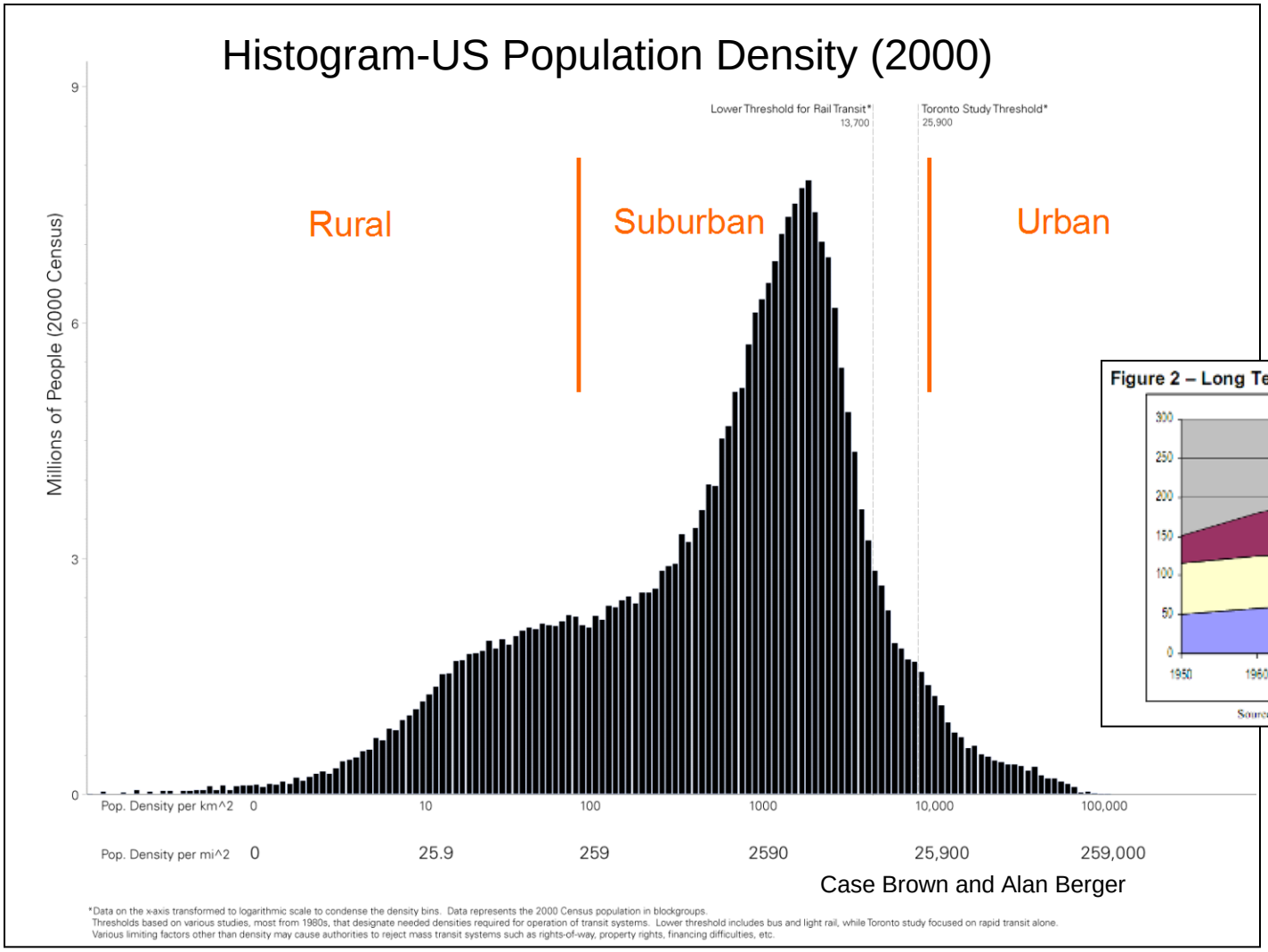


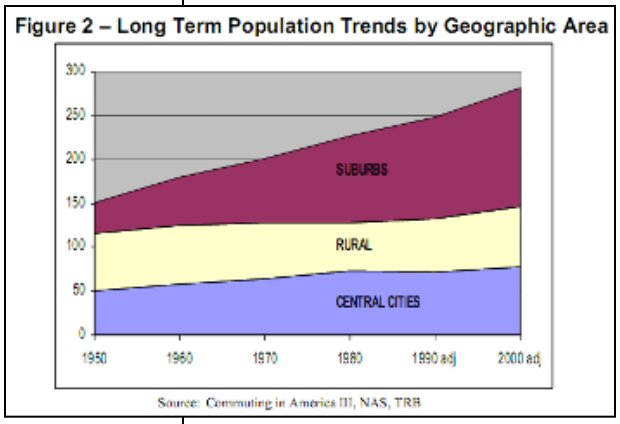


More new residents in Florida than Northeast and Midwest combined.

(Same is True for Texas. Same is true for California)

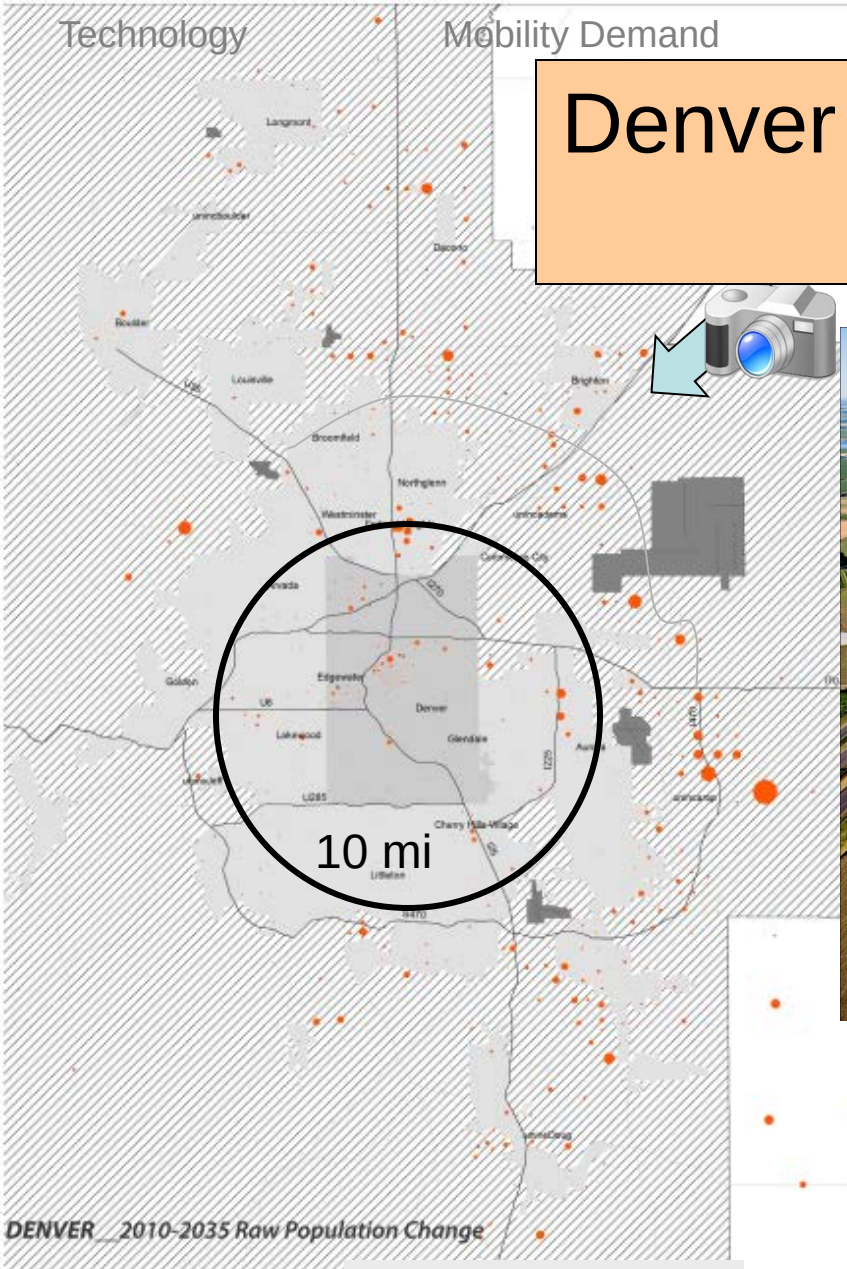
Americans Mostly Live in Suburb-level Density





Clearly, the "high-density" culture is rare in the US

Denver Population Density Change 2010-2035



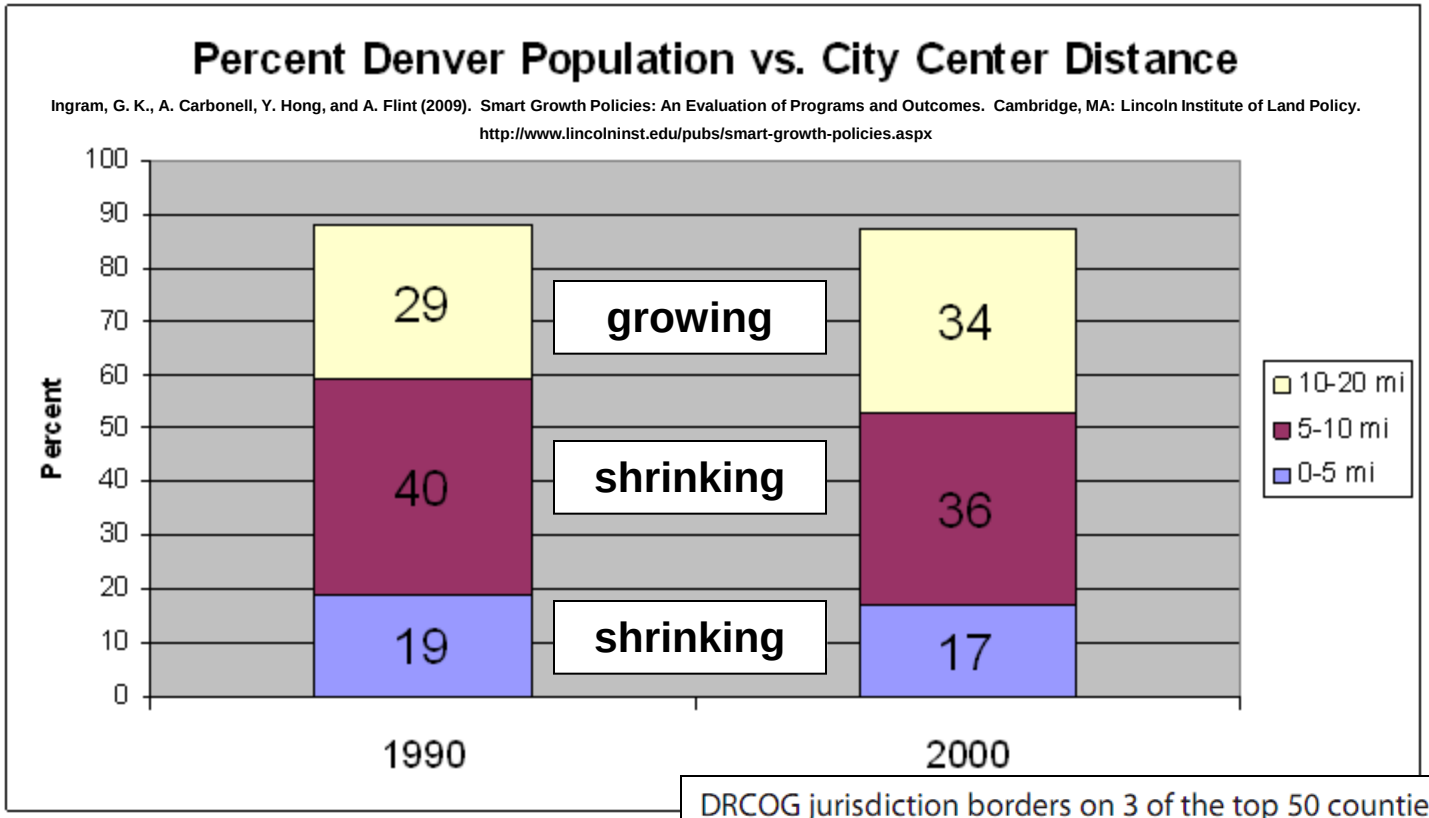
- Growth is strong in periphery
- New Housing is located to provide convenient access to highway

Alan Berger and Case Brown

Data: Denver Regional Council of Governments (DRCOG)

Denver Population is Decentralizing (by %)

Selection criteria for Denver is on slides 44, 45



DRCOG jurisdiction borders on 3 of the top 50 counties, capturing much of their main growth areas

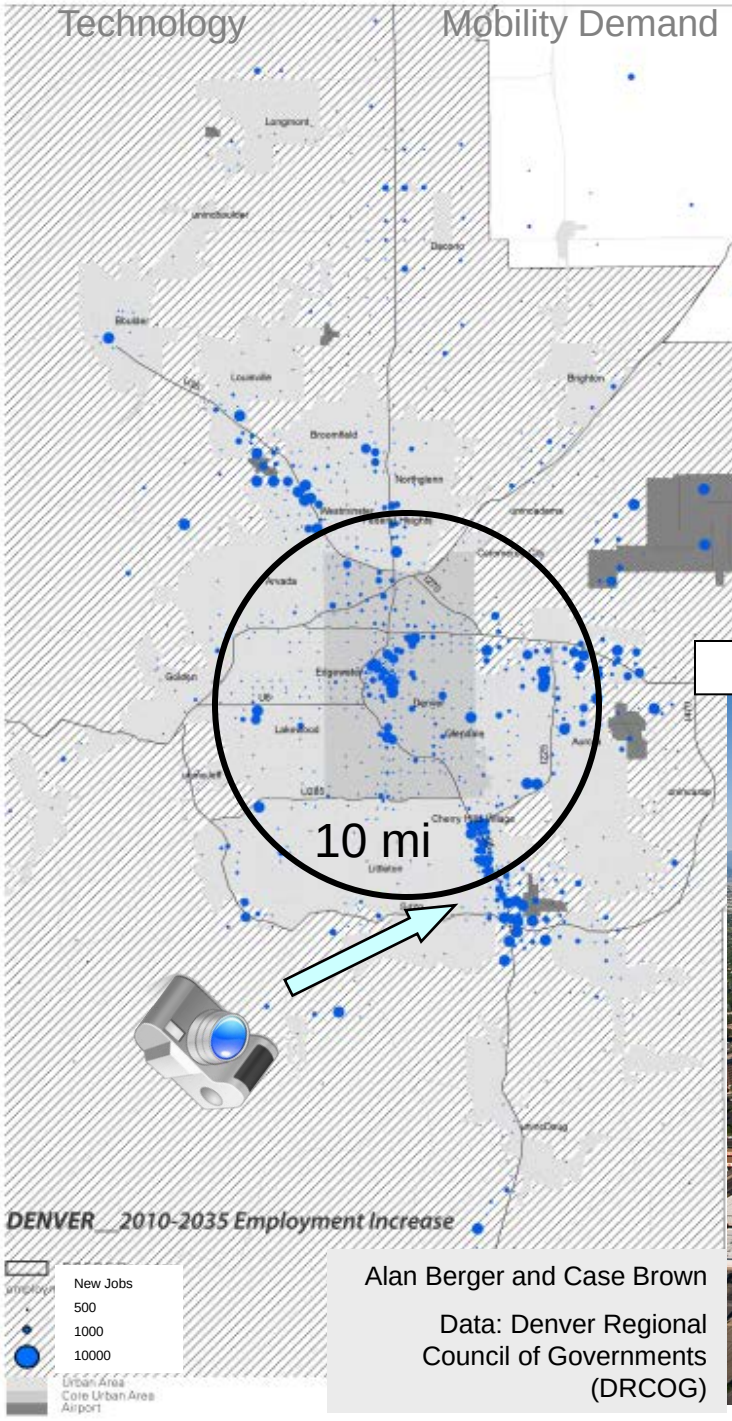
SOUTH-Douglas County, 12th, grew 60.2% from 2000-2008
NORTH-Broomfield County, 35th, grew 44.4%
NORTHEAST-Weld County, 43rd, grew 42.0%

Employment

Denver 2010-2035 Employment Increase

Predicted Growth Strongly Tied to Highway (and Airport)

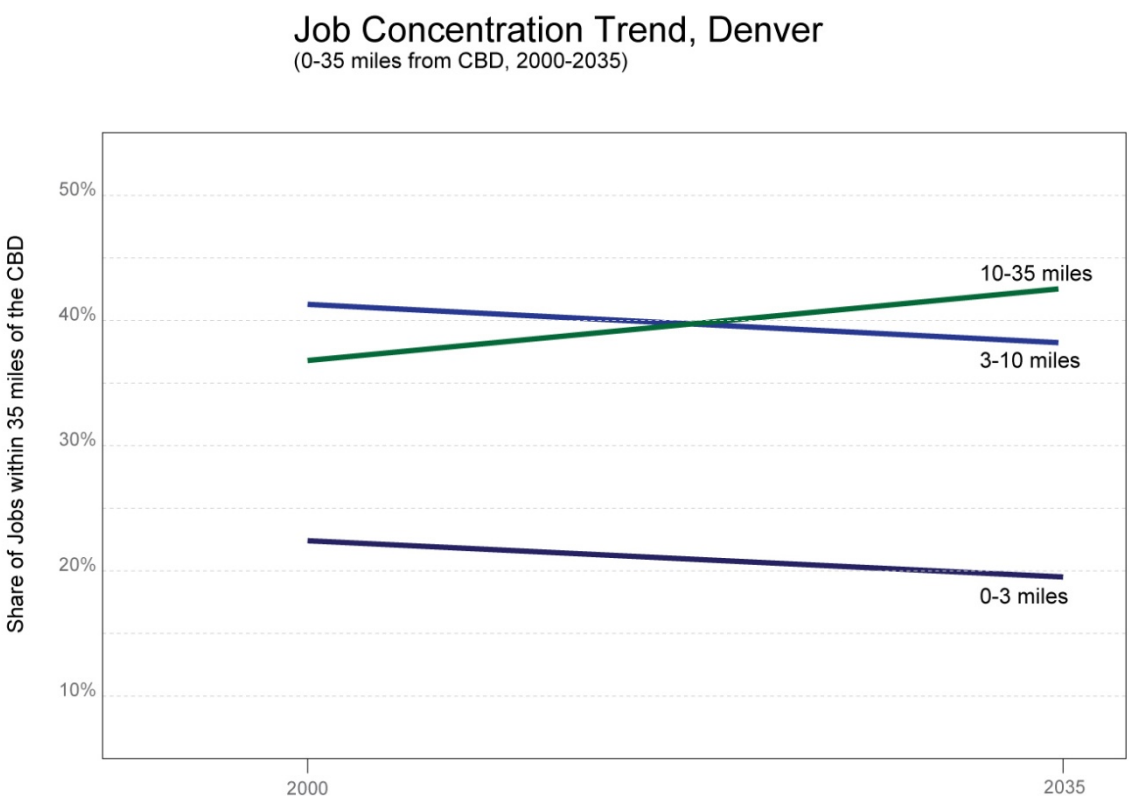
Alan Berger and Case Brown



Alan Berger and Case Brown

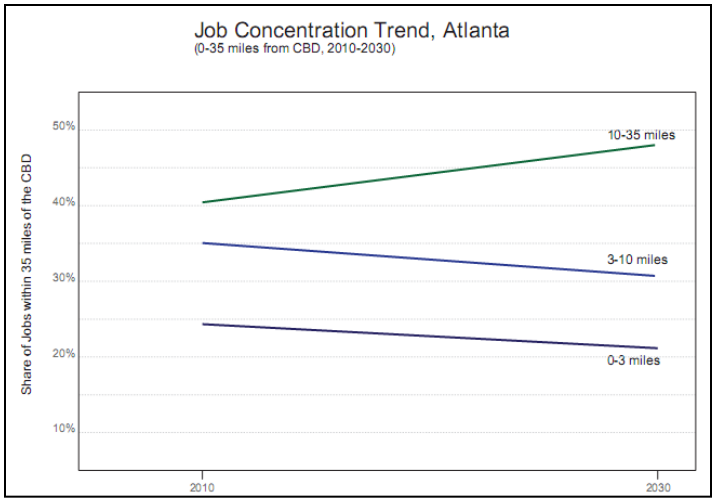
Data: Denver Regional Council of Governments (DRCOG)

Denver 2010-2035 Employment Regional Share



- Majority of jobs will soon be > 10 mi from Central Business District (CBD)
- Outer suburbs only region growing in share of jobs.

for comparison



In Atlanta, trend is even stronger

Compare Atlanta to Denver

	Atlanta	Denver
Population (2007)	5279k	2464k
Population Growth (2000-2007)	24%	13.1%
New Urbanized land between 2000-2035 (mi^2)	275	190
Fraction of jobs 10-35 mi from city in 2035	49%	43%
Fraction Commuters using Mass Transit (2000)	2.6%	2.1%
Current Fraction VMT on Freeway+Expressway	39%	44%
Current Fraction VHT on Arterials	44%	31%

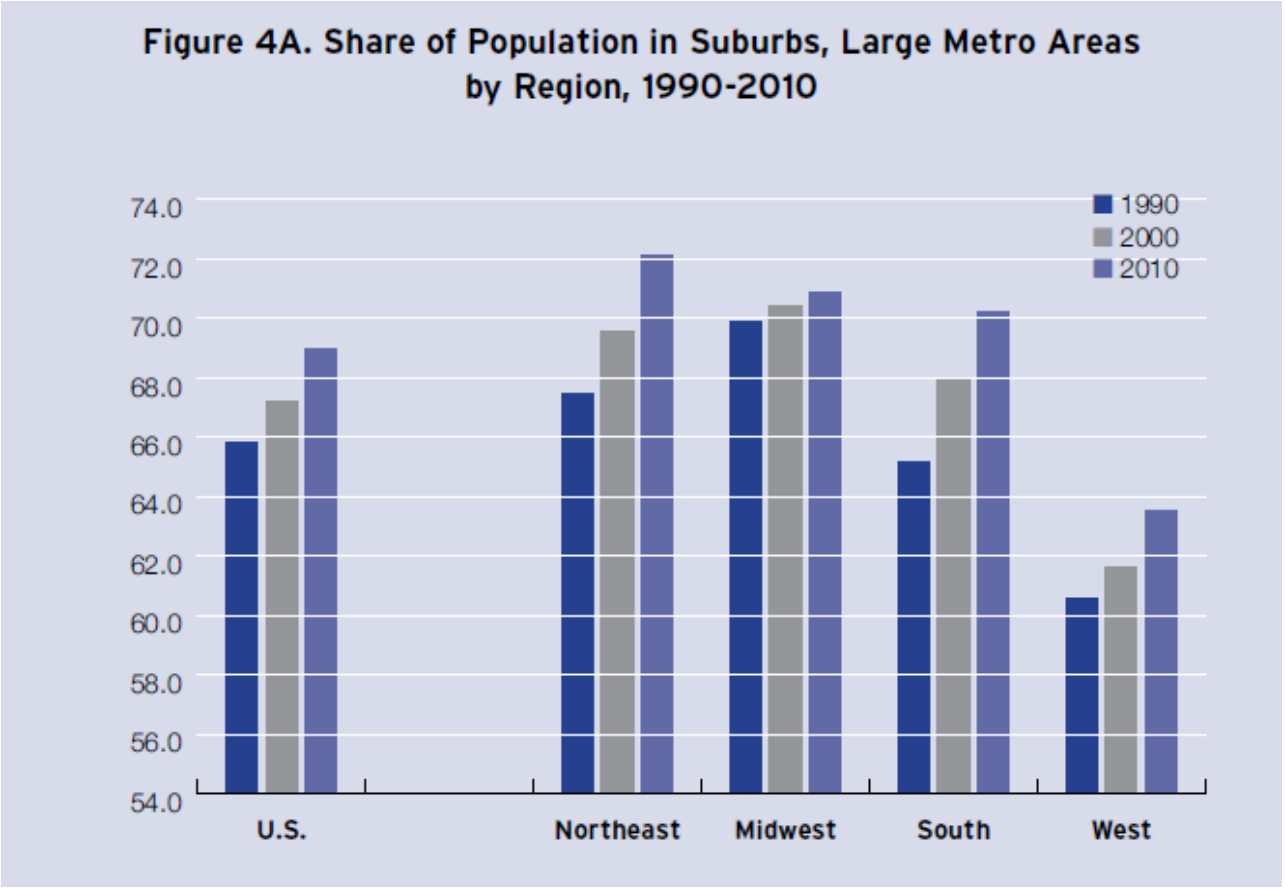
Similar:

1. Large Edge Growth
2. Over 43% jobs 10-35 mi from city (2035)
3. Negligible Mass Transit

Different:

1. Atlanta 2x in population and growth
2. Atlanta already overwhelms highways, must heavily rely on arterials

Suburbs are growing in every US Region



US Suburbs share of population grows the last 20 yrs, in every region. [Source: W. Frey, Brookings Inst., 2012]

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Observation: Emerging Image of US Driver

The attributes and trends of the US driver:

1. Drives more as wealth increases (Slides 16, 22)
2. Lives in suburbs, works in suburbs, drives between suburbs. (Slides 8, 9, 10, 11, 12, 13, 25, 57, 63, 75). These suburbs are moving further from metro center. (Slides 58, 59)
3. Commutes alone by car (Slides 14, 15, 71)
4. Commute distance is increasing (Slide 26)
5. Drives an increasing fraction of miles on non-stop roads (e.g. highways) (Slides 38, 48)
6. Despite lower price, mostly ignores mass transit (unless it provides a convenience/time advantage) (Slides 14, 71)
7. Lives in the South and West of US, where the above conditions are especially strong. (Slides 6, 7, 80, 82)

Due to frequent updates to this presentation, the above slide numbering may be wrong. A version with correct numbering can be found at https://sites.google.com/a/laberteaux.org/motm/

Intentionally Provocative Question (my opinion only):

For USA, where should we focus our efforts?

HERE? *last-mile problem*

OR HERE? *many-mile problem*

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Backup Slides

Why Denver?
Selection Criteria (1/2)

A) Top 100 Metropolitan Area by population: *Rationale: Vast majority of the American economy found within this set (75% of U.S. economy, 62% of population, 9.2% growth from 2000-2008)*

B) Located in South or West regions *Rationale: Growth potential is at least triple that of North or Midwest (South and West grew at 12% from 2000-2008, East and Midwest only 3%)*

C) Metropolitan Area, not Micropolitan Area *Rationale: Growth in Metros is twice that of Micros (9.2% for Metros vs. 4.5% for Micros from 2000-2008)*

C) Should not be limited on more than 1 side geographically *Rationale: Oceans, mountains, geographical limitations for expansion can exert strong natural controls on urbanization that will not be typical of the overall set*

Why Denver?
Selection Criteria (2/2)

E) Not an outlier in terms of growth/size/etc. *Rationale: New York City and Los Angeles have economies of scale unlike other metros. Might include metrics like "Gross Metropolitan Product" that ensures the chose metro acts like a typical metro in economic performance (ie, not too focused on retirement or one single industry for its projected growth)*

F) Regional government entity and coordination *Rationale: Because we are looking at entire metropolitan areas which mark a census definition and overlap multiple political entities, we need to find a representative area that coordinates different city data across a major portion of a metropolitan area.*

G) Data Availability *Most metros will not have data on outlying areas, which are critical for this analysis.*

Outcome: Criteria *a-f* produced only two candidates: Denver-Aurora and Greenville-Mauldin-Easley, but **Denver-Aurora** had clearly the largest available data, and was the final choice.

Why Atlanta?

Criterion 1
Top 100 Metropolitan Areas in population *(Atlanta is 9th)*

Criterion 2
Located in the South or West regions *(Atlanta is in the South region)*

Criterion 3
Metropolitan Area, not Micropolitan *(Atlanta is a Metropolitan Area)*

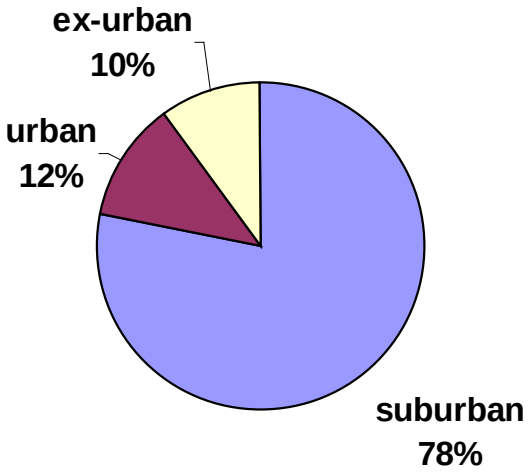
Criterion 4
Not limited geographically (0-1 sides) *(Atlanta is unrestricted on all sides)*

Criterion 5
Growth/size outlier *(Atlanta shows largest absolute growth from 2000-2007 of all Metros)*

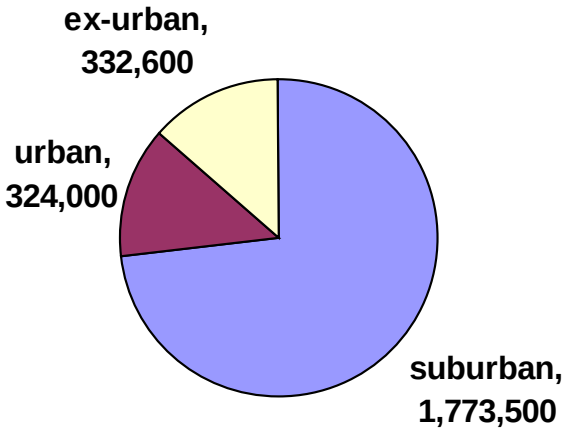
Criterion 6
Regional government entity/coordination *(Atlanta Regional Commission, ARC, active)*

Criterion 7
Data Availability *(ARC maintains comprehensive dataset and projections)*

Atlanta population growth remains primarily suburban



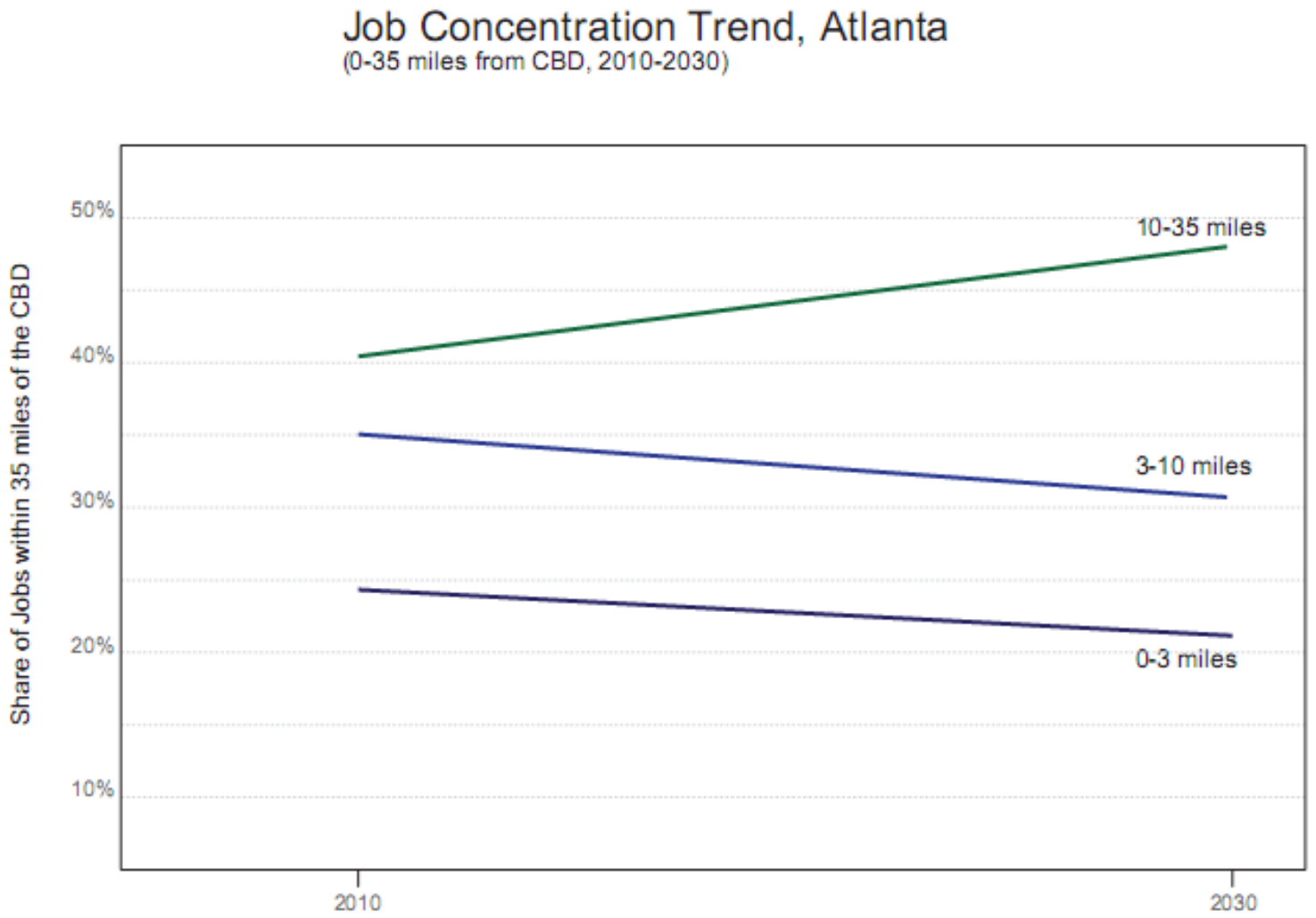
1980-2000



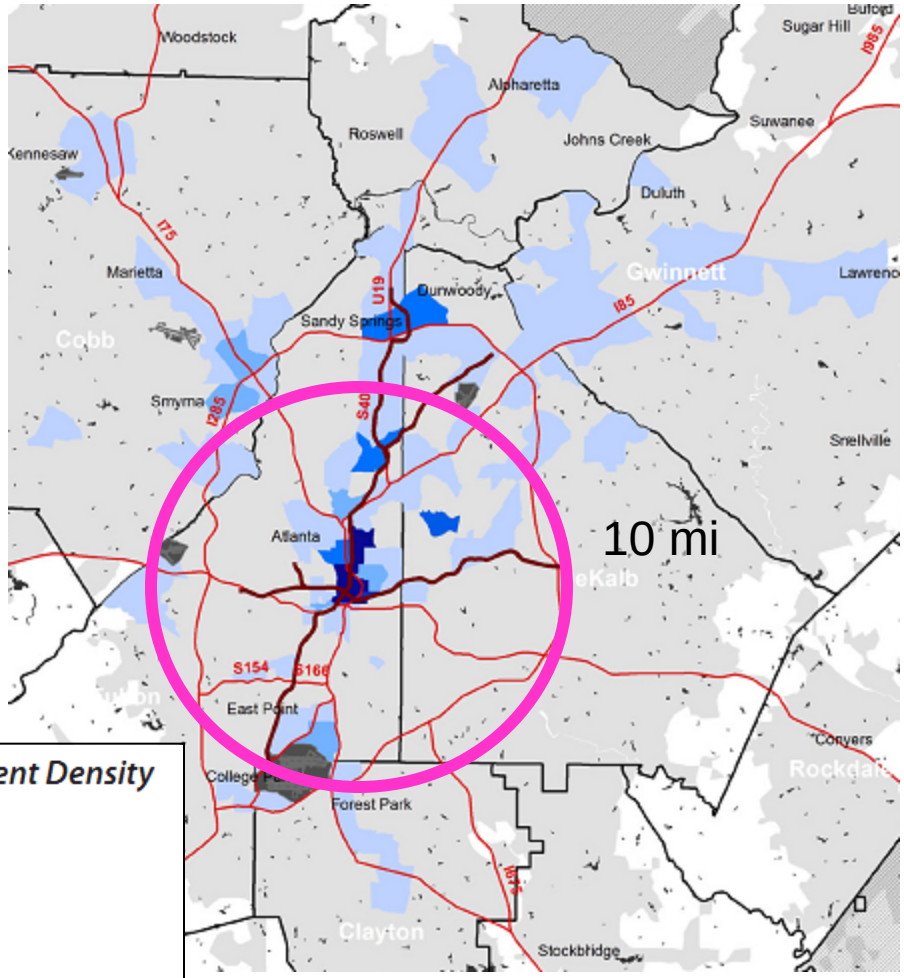
2000-2030 (est)

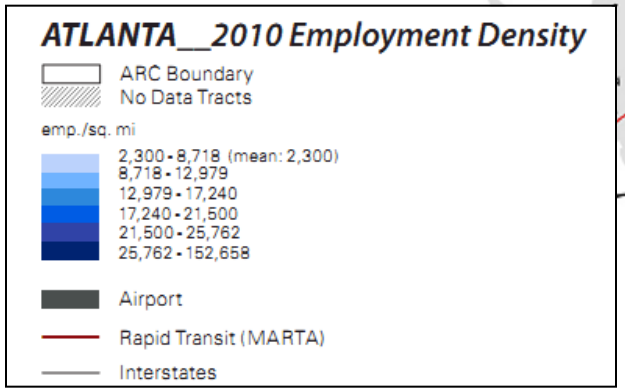
Regional Breakdown [urban, suburban, ex-urban (distant suburb)] of new population in Metro Atlanta

Distribution of Employment in Metro Atlanta



2010 Employment Density-Atlanta





All blue areas have above-average employment density

Mapping by Case Brown, Alan Berger

Atlanta-Commute by car

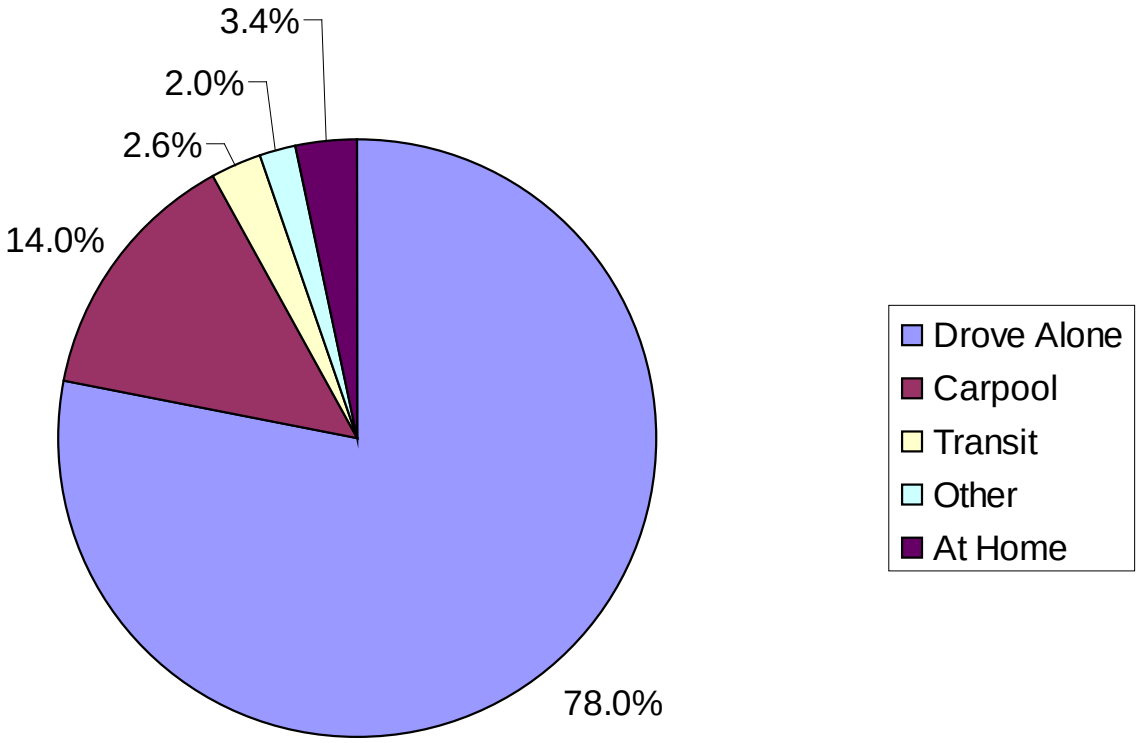
ATLANTA REGIONAL COMMISSION ON-BOARD SURVEY (2010)

63.6 | Percent of Transit Riders who had no vehicle available

80 | Percent of Workers drove alone in Atlanta, 2000

(FHWA/USDOT. Journey to Work Trends in the United States and its Metropolitan Areas, 1960-2000. Publication No. FHWA -EP-03-058. 2003.)

Atlanta-Car Commute Dominates

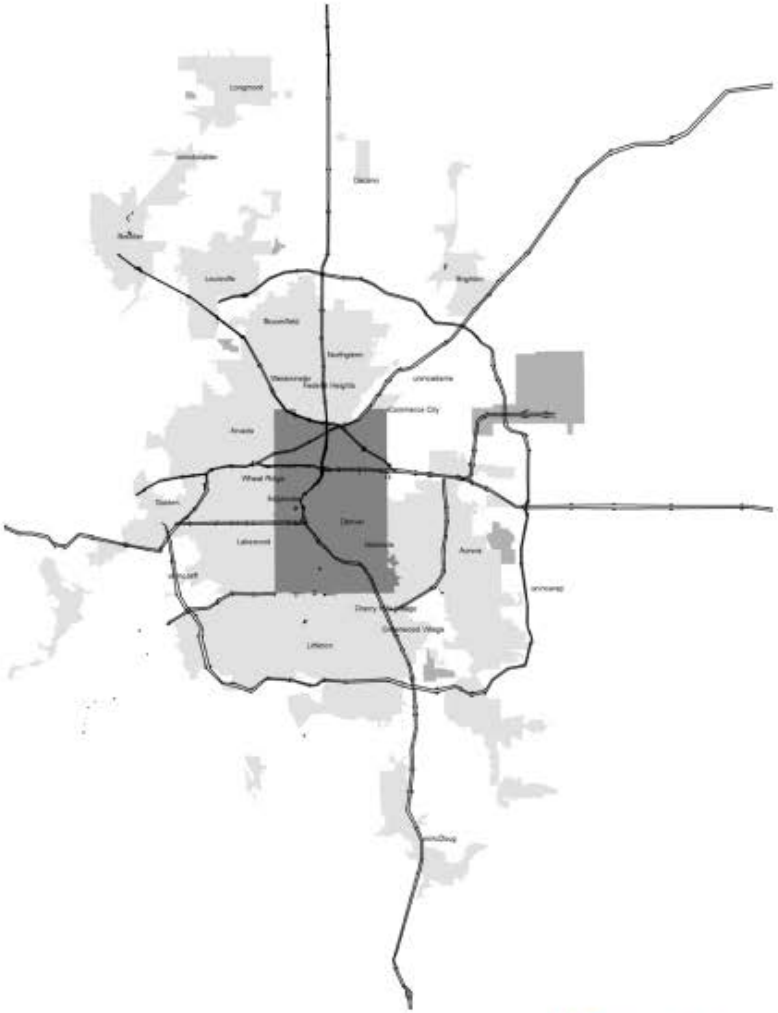


Atlanta-Transportation Method for Workers (2000)

Car 92%

Transit 2.6%

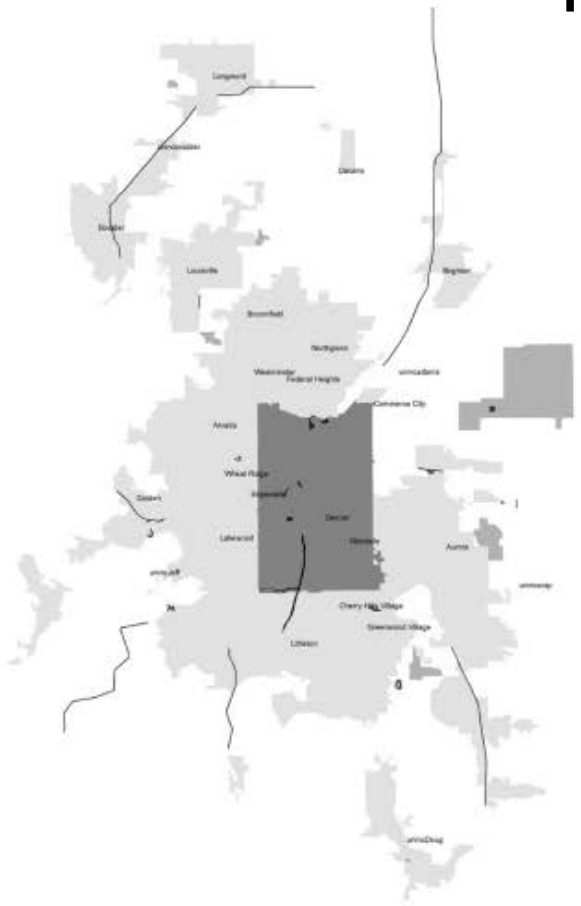
“Non-stop” driving



Freeways

24% VHT / 38% VMT

Most critical in terms of Miles Traveled (see pg. 41)



Expressway

4% VHT / 6% VMT

Freeway +Expressway = 44% VMT

Other Regional Differences

MSA Name		Workers			Jobs		
		1980	1990	2000	1980	1990	2000
Atlanta	Area wide	1,033,088	1,542,948	2,060,632	1,011,212	1,583,146	2,120,887
	Central	24.4	20.4	18.7	43.8	36.1	33.8
	Suburban	68.9	72.8	73.1	51.6	59.5	61.2
	Ex-urban	6.7	6.8	8.2	4.6	4.4	4.9
Chicago	Area wide	3,575,803	3,922,295	4,218,108	3,535,802	3,949,498	4,263,429
	Central	63.8	60.4	56.2	69.5	65.1	59.9
	Suburban	31.8	35.1	38.8	26.9	31.2	36.2
	Ex-urban	4.4	4.5	5	3.6	3.7	3.9
Denver	Area wide	859,989	1,026,847	1,346,025	843,345	1,038,584	1,366,376
	Central	28.2	22.5	20.7	46	36.4	31.8
	Suburban	65.6	71.4	72.9	48.8	58.2	63
	Ex-urban	6.1	6	6.4	5.2	5.4	5.2
Minneapolis	Area wide	1,081,772	1,344,797	1,595,550	1,062,619	1,361,205	1,628,481
	Central	45	41.7	38.1	53.4	51.9	49.6
	Suburban	46.7	49.2	51	41.4	42.4	43.8
	Ex-urban	8.3	9	10.9	5.2	5.7	6.7
Portland	Area wide	704,392	861,141	1,105,133	689,559	860,743	1,107,079
	Central	37.1	33.3	30.3	50	43.9	39
	Suburban	45.5	49.4	52.3	33.7	39.8	45
	Ex-urban	17.4	17.3	17.4	16.3	16.3	16

- Atlanta (South) and Denver (West) are growth areas, with Denver most typical. Suburbs dominate.
- Chicago and Minneapolis (Midwest) have higher fraction at city center.
- Portland (Northwest Coast) has very high fraction of Ex-urban.

We should not generalize, especially outside South and West.

Table 3.9 **Percent Distribution of Metropolitan Area Population in Concentric Rings, 1990 and 2000**

	0- to 5-Mile Ring			0- to 10-Mile Ring			0- to 20-Mile Ring		
	1990	2000	Change	1990	2000	Change	1990	2000	Change
SMART GROWTH STATES									
Portland	28	24	-4	Portland	66	62	-4	Jacksonville	91	91	0**
Jacksonville	25	20	-5	Jacksonville	58	50	-8	Portland	89	89	0**
Baltimore	22	18	-4	Orlando	54	48	-6	Orlando	83	81	-2
Orlando	21	16	-5	Baltimore	44	39	-5	Newark	78	77	-1
Newark	16	15	-1	Newark	40	40	0**	Miami*	76	75	-1
Miami	15	12	-3	Camden	36	34	-2	Camden	70	72	2
Camden	14	13	-1	Miami	36	31	-5	Tampa	68	68	0**
Tampa	10	9	-1	Washington (MD)	31	29	-2	Washington (MD)*	68	66	-2
Ft. Lauderdale	9	8	-1	Ft. Lauderdale	29	26	-3	Baltimore*	67	65	-2
Washington (MD)	1	1	0**	Tampa	27	26	-1	Ft. Lauderdale*	67	69	2
Average	**16**	**14**	**-2**	**Average**	**42**	**38**	**-4**	**Average**	**76**	**75**	**-1**
OTHER SELECTED STATES									
Austin	29	23	-6	San Antonio	67	59	-8	San Antonio	93	91	-2
San Antonio	29	24	-5	Austin	60	52	-8	Denver	88	87	-1
Richmond	25	22	-3	Denver	59	53	-6	Indianapolis	85	85	0**
Indianapolis	23	18	-5	Indianapolis	58	51	-7	Richmond	84	84	0**
Denver	19	17	-2	Richmond	57	52	-5	Austin	84	83	-1
Houston	11	9	-2	Washington (VA)	39	28	-11	Houston	81	78	-3
Fort Worth	11	9	-2	Houston	35	31	-4	Washington (VA)	75	69	-6
Dallas	10	8	-2	Dallas	31	27	-4	Dallas*	75	71	-4
Washington (VA)	9	8	-1	Fort Worth	31	28	-3	Virginia Beach	74	71	-3
Virginia Beach	6	5	-1	Virginia Beach	24	24	0**	Fort Worth*	62	60	-2
Average	**17**	**14**	**-3**	**Average**	**46**	**41**	**-5**	**Average**	**80**	**78**	**-2**

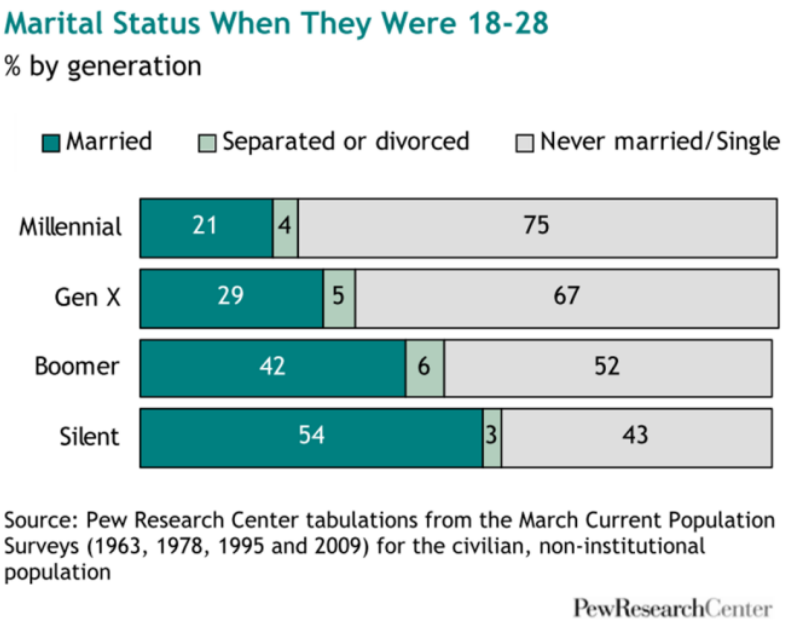
*Ring overlaps with rings in another metropolitan area.
**The number appears as zero because of rounding.
Notes: All rings are measured from the CBDs of the metropolitan areas as defined by the 1982 Census of Retail Trade.
Metropolitan area names are shortened for simplicity and are listed in descending order based on 1990 census data in each ring and in each set of states.

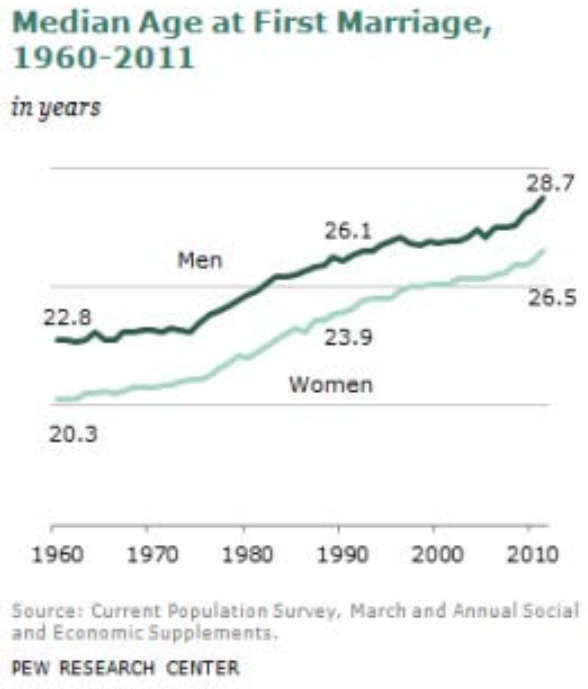
Source: U.S. Census Bureau (1996; 2006b).

Ingram, G. K., A. Carbonell, Y. Hong, and A. Flint (2009). Smart Growth Policies: An Evaluation of Programs and Outcomes. Cambridge, MA: Lincoln Institute of Land Policy.
http://www.lincolninst.edu/pubs/smart-growth-policies.aspx

Gen Y: Life-cycle effect is delayed

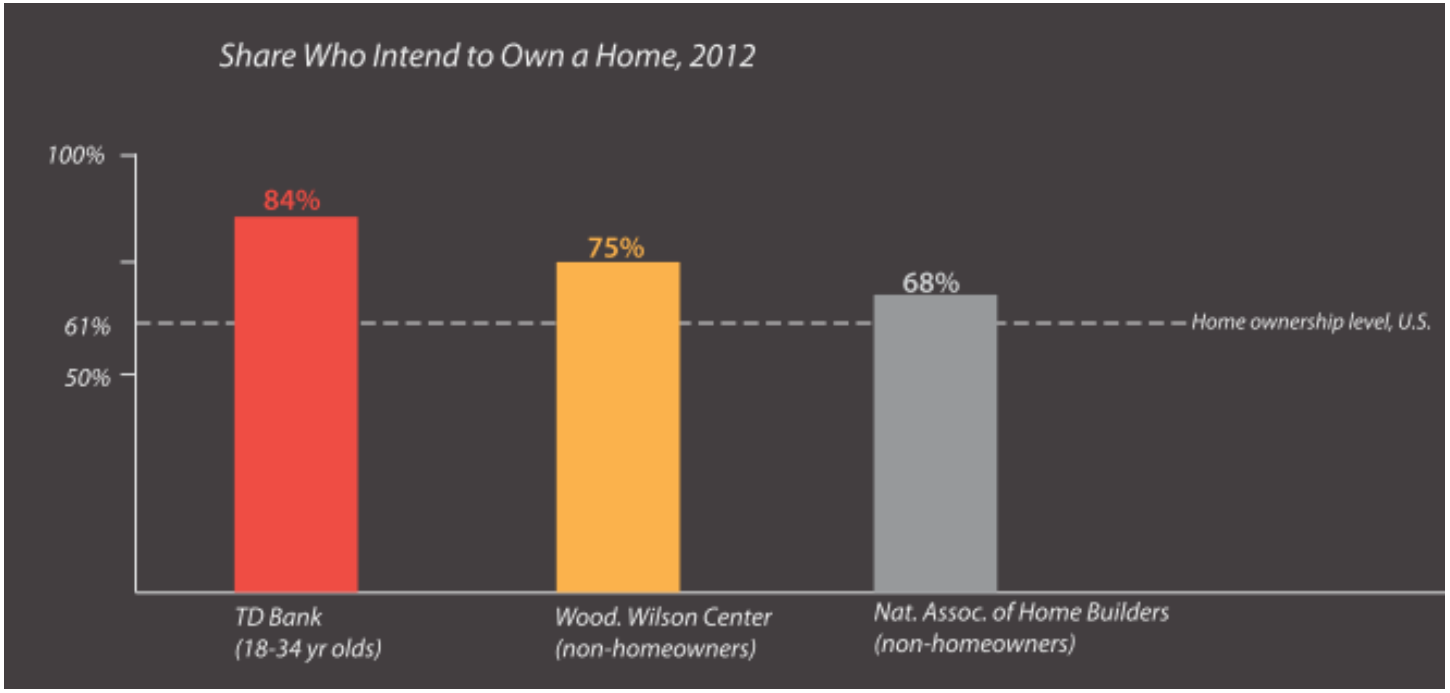
- *Life-cycle effect* describes the effect that people's priorities change at different stages of their lives.
- Compared to previous generations, Gen Y's transition to married/family life is delayed.





Gen Y: Still want Homes

- TRI-NA reviewed several respected surveys
- Conclusion: Gen Y thinks owning a house is important, and plan to do so



Gen Y: Still want a Family

- Conclusion: Gen Y thinks marriage and having a family is important, and plan to get married and have children.