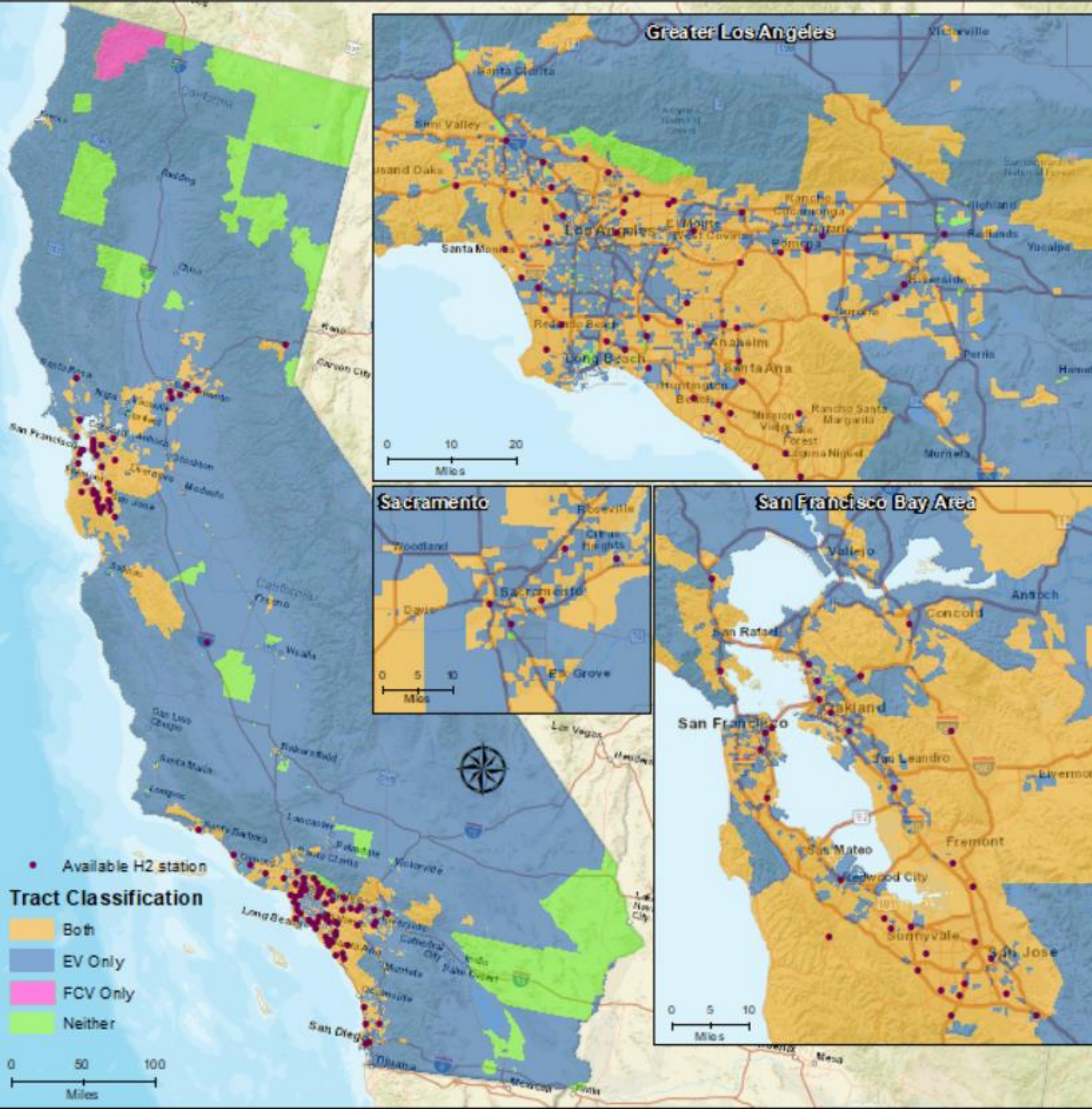# Characterizing Early Hydrogen Fuel Cell Vehicle (FCV) Adopter Neighborhoods in California

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Assistant Professor
Department of Geography

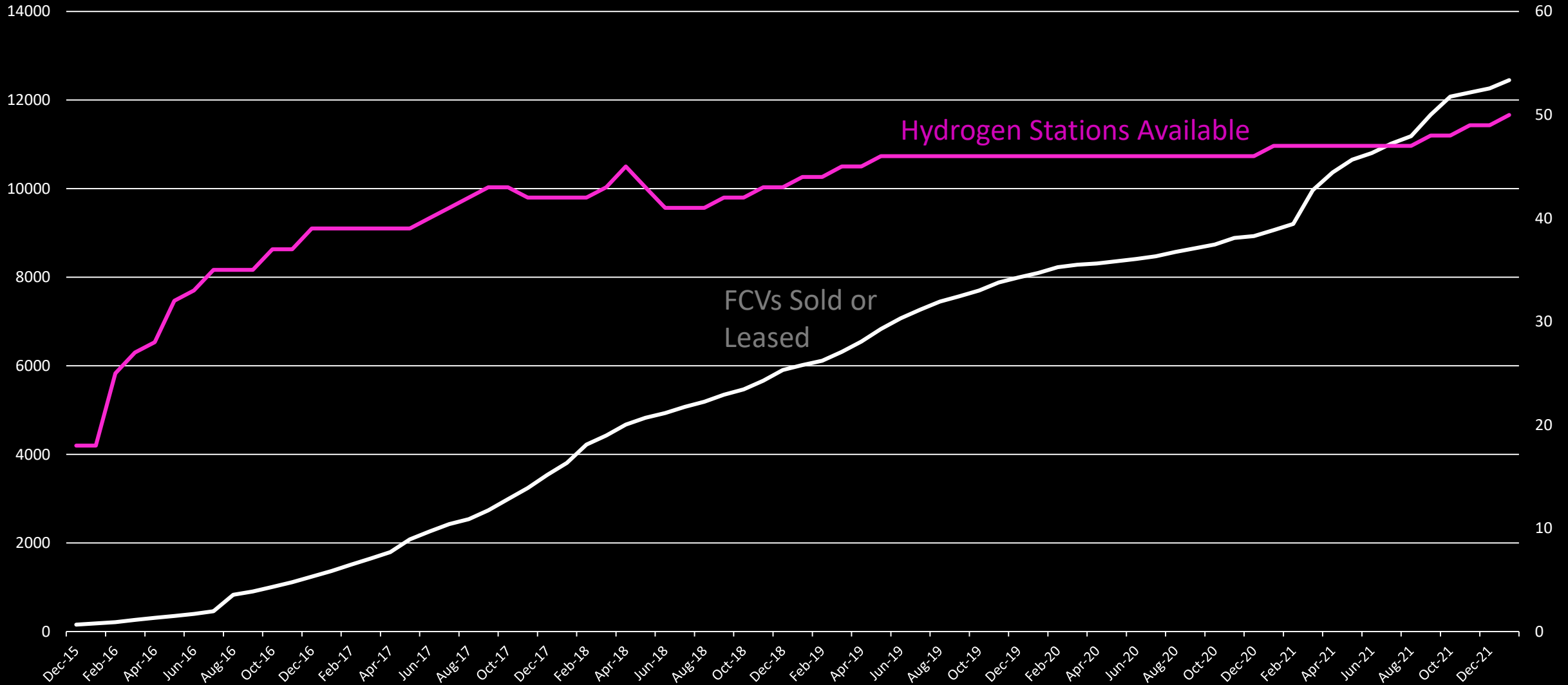University of Nevada, Reno

American Association of Geographers
Annual Meeting
February 26th, 2022

**Vehicles and Stations
2015 - 2022**

Vehicles

Stations

Hydrogen Stations Available

FCVs Sold or Leased

Source: California Fuel Cell Partnership "By the Numbers"

Spatial Analysis of H2 Uptake

RQ: Are there areas in California where FCVs are adopted at relatively higher rates compared to EVs?

1) What are the common characteristics of these areas, considering:

    a) Access to stations?

    b) Correspondence with BEV/PHEV adopters?

    c) Demographics and Employment?

2) How does this compare to past attempts to identify demand?

Consumer Adoption of FCVs

- Vehicle **amenities**, **performance, "fit"** between vehicle and driver, **symbolism**
  (Hardman et al. 2018; Lopez et al. 2019)
- **Number** and **spatial distribution** of **stations to home, work, commute route, activities**
  (Kitamura and Sperling 1987; Kuby and Lim 2005; Ogden and Nicholas 2011; Kang and Recker 2014; Zhang et al. 2016; Brey et al. 2017; Ramea 2019)
  - Drivers assemble **portfolios of multiple stations** to satisfy geographic criteria *(Kelley et al. 2020)*
  - Drivers **add** stations **further away from home** after experience *(Krafft et al. 2021)*
- **Compared** to EVs:
  - Lower Cost, No Ability to Reliably Recharge at Home, Shorter Refueling Times *(Stotts et al. 2021; Lopez et al. 2019)*

Technology

Tesla CEO Elon Musk On Hydrogen Cars: It's 'Mind-Bogglingly Stupid'

By Lorraine Lorenzo
02/24/19 AT 8:53 PM

Elon Musk's Tesla cars may have changed the way we look at sustainable driving, but the company's CEO remains unconvinced that hydrogen cars are the way of the future and even called the idea "mind-bogglingly stupid."

Hydrogen Station Locations: Consumer Demand

Table 1. Attributes Affecting Hydrogen Vehicle Adoption by Consumers

Attribute	Impact	Rationale
Households with Two or More Vehicles	High	Households with multiple vehicles more likely to adopt hydrogen vehicles
Education	Medium	Higher education leads to earlier adoption
Household Income	High	Higher incomes lead to earlier adoption
Commute Distance	Medium	More time spent in a vehicle commuting interests consumers in newer and more efficient vehicles
State Incentives	Medium	Alternative fuel vehicle incentives could indicate future or existing hydrogen incentives
Clean Cities Coalitions	Medium	Coalitions pull funding opportunities together and create alternative fuel awareness
Air Quality	Medium	Low air quality leads to educated consumers and incentives
Hybrid Vehicle Registrations	Medium	Early adopters of new gasoline vehicle technologies could be early adopters of new hydrogen vehicle technologies
Zero-Emission Vehicle (ZEV) Sales Mandate	Medium	Hydrogen vehicles qualify for these mandates

Other Approaches:
- Scenario Evaluation and Regionalization Analysis (SERA)
  - FCEVs and BEVs
  - Infrastructure and Vehicles
  - Early Adopter Metric for FCEVs
    (**50% other advanced vehicles, 25% luxury, 25% income**)
- Spatially and Temporally Resolved Energy and Economy Tool (STREET)
  - Network planning, but adopter locations come from data from auto manufacturers + **hybrid adoption**
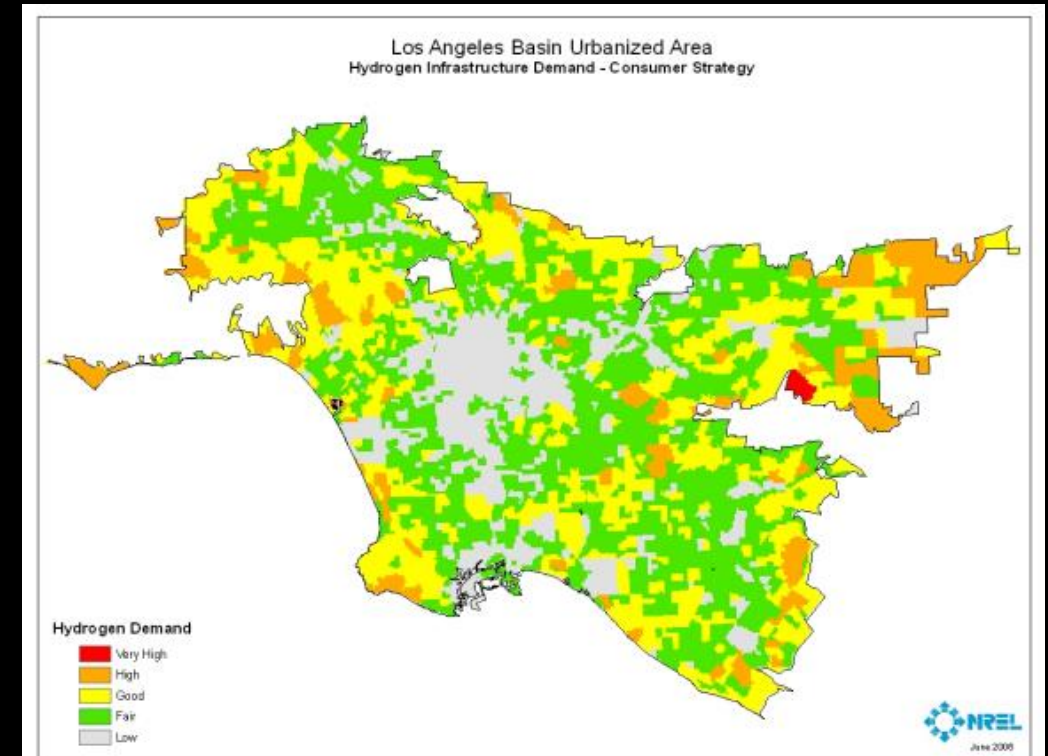

Figure 5. Hydrogen Vehicle Demand—Consumer Strategy Baseline Scenario, Los Angeles Basin

California Hydrogen Infrastructure Tool (CHIT)
- Scenario planning for new stations
- **Income, education, luxury vehicle adoption, vehicle sales with prices similar to FCEVs, adoption of HEVs and PHEVs (not BEVs), commuter traffic**

Data

Zero-Emission Vehicles: Hydrogen Fuel Cell

- California Clean Vehicle Rebate Project (*CVRP*)
  - Individual, 2015-present, Census Tract
  - **Counts** of: FCVs, BEVs, PHEVs
  - **Low-/Moderate-Income** Increased Rebates
    - <= 400% of federal poverty level, +$2500
    - ex. HH size of 3, cap is $86,880
  - Increased rebates for fleets also allowed in **Disadvantaged Communities** (DACs)
  - <u>Limit</u>: individuals who did not apply
- Alternative Fuels Data Center
  - Public retail H2 stations (available and planned)
    - 10-minute (*Brey et al. 2016, 2017; Martin et al. 2009*)
    - 25-minute (*Kelley et al. 2020*)
  - Public Charging (DCFC, L2)

- Demographic & Employment
  - Two or more vehicles
  - Bachelors Degree or Higher
  - Commute greater than 20 min.
  - High Income ($100k or more)
  - Multi-Family Housing
  - High-Paying Jobs (>$3,333/month)
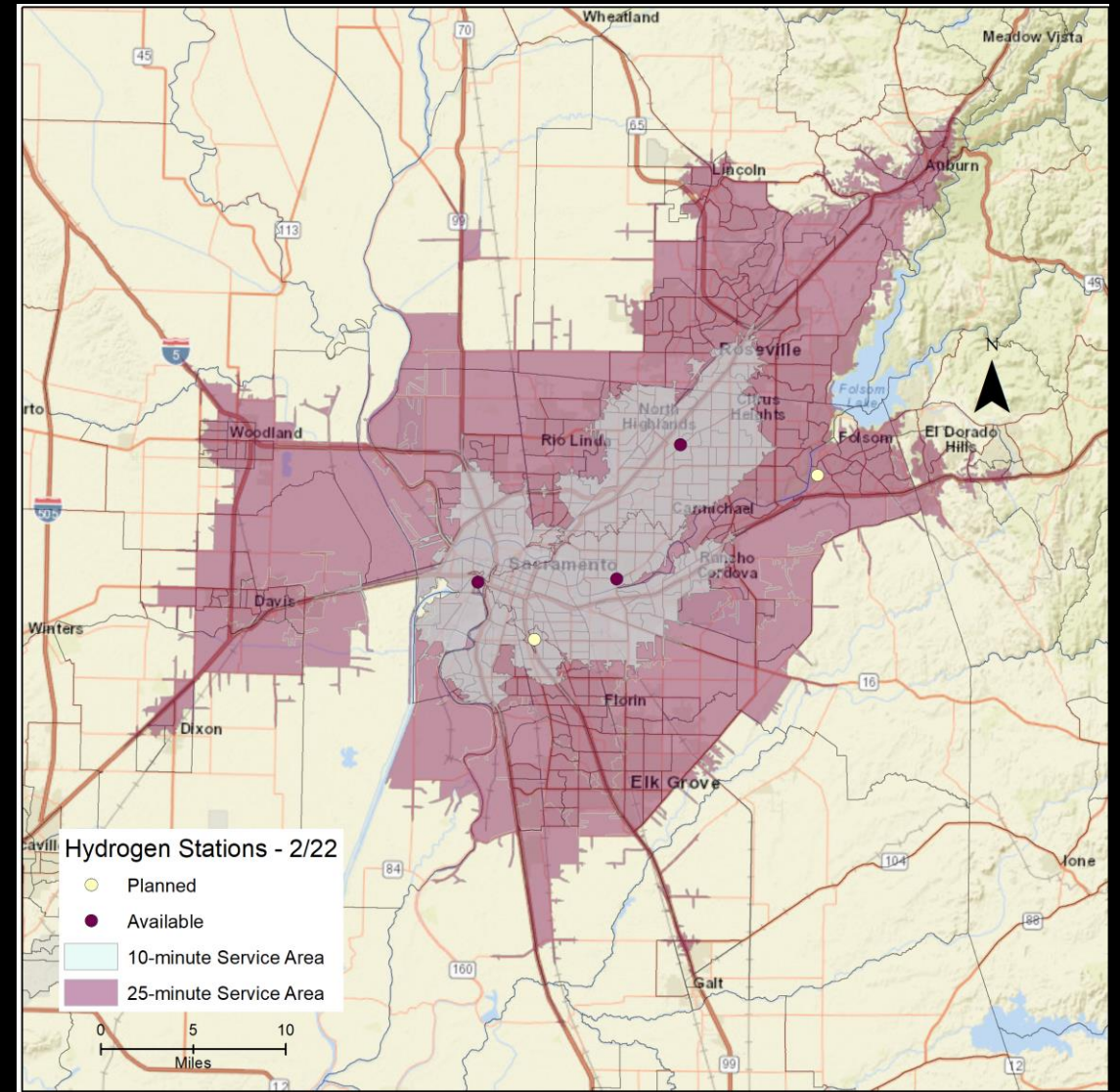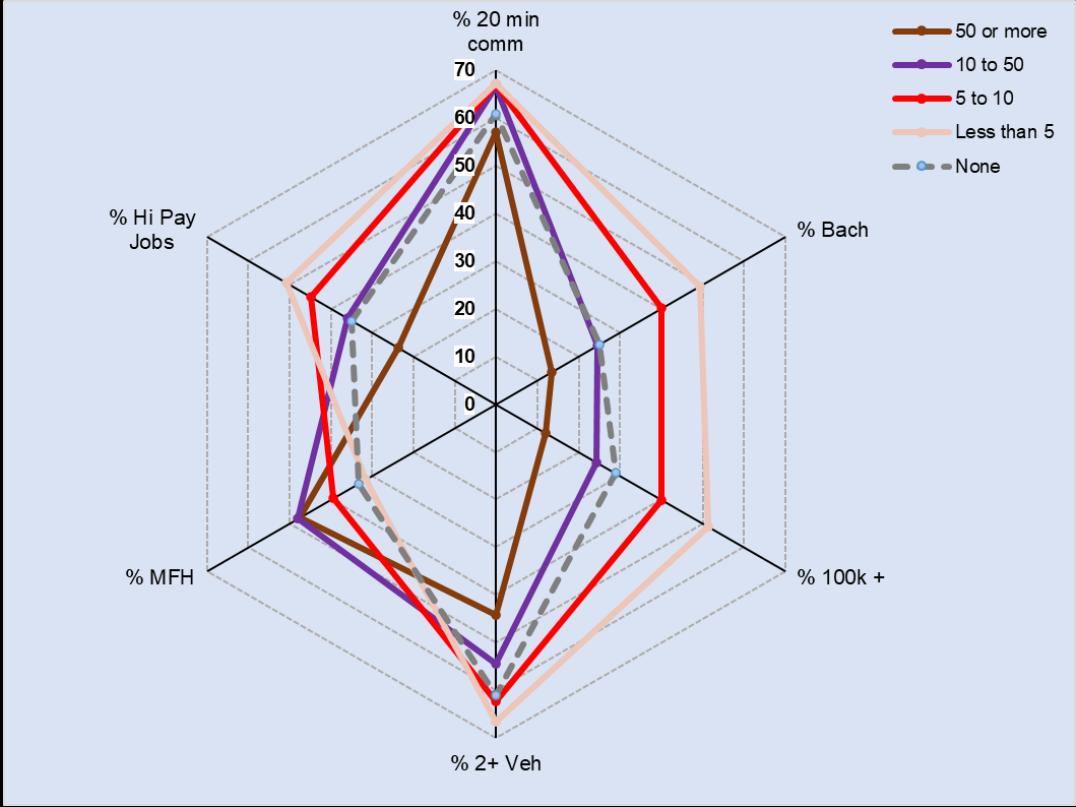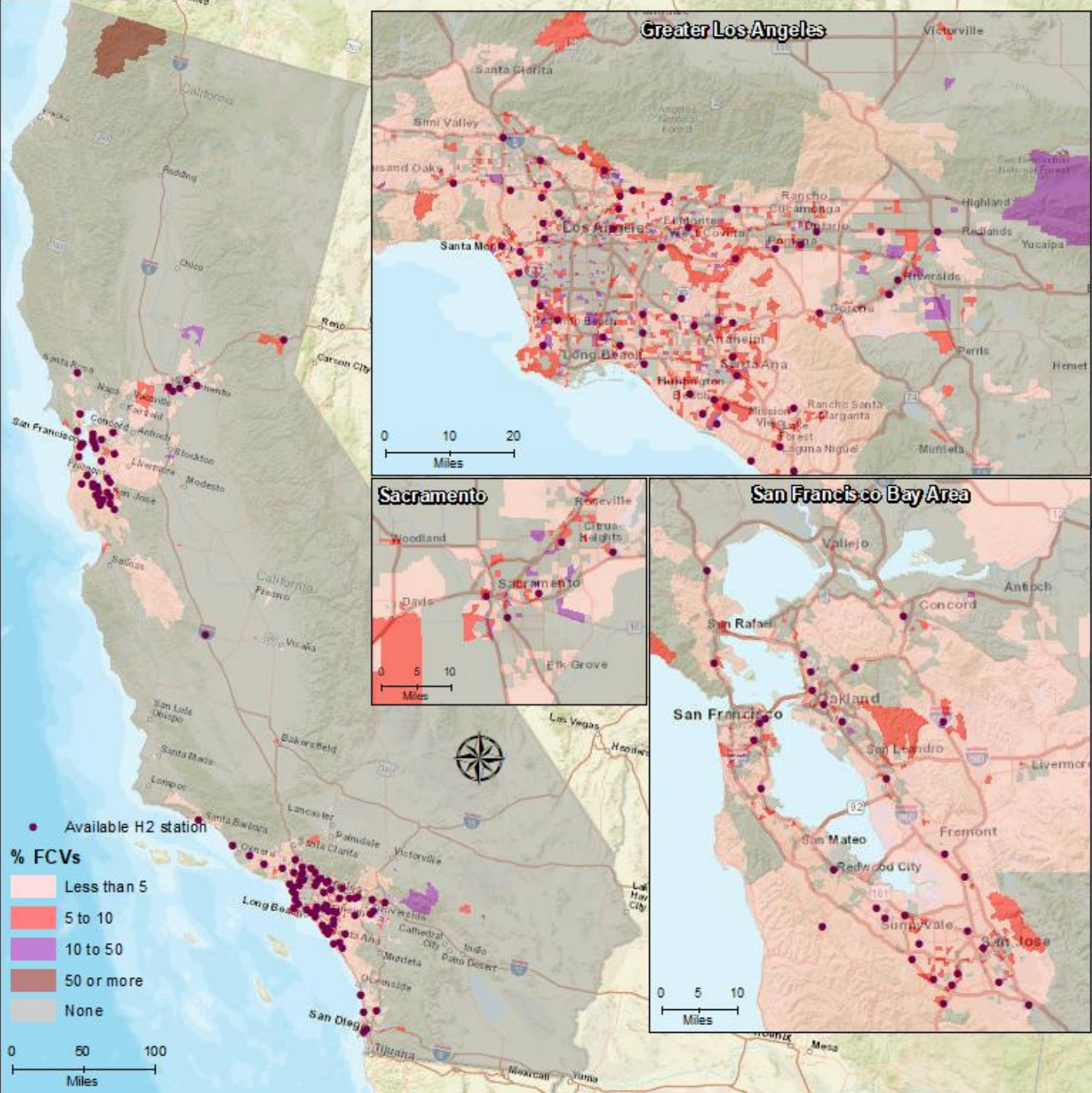
Methods

Access to Stations
- H2, DCFC, L2 *in* Tract
- H2, DCFC, L2 *near* Tract
  - Network Analyst
  - Majority Overlap with Tract Boundary
  - Assumes free-flow travel times
  - Separate for:
    - H2 available, planned
    - 10, 25-minute
    - DCFC 10-minute

- Categorizations of Tracts
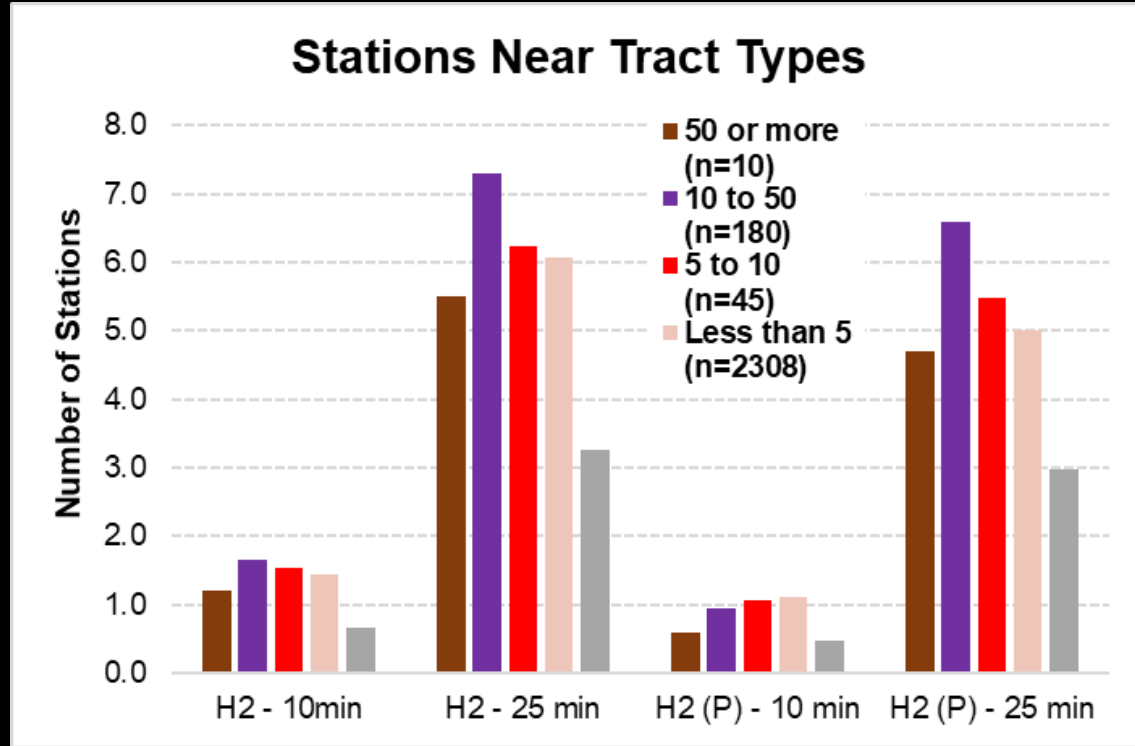 - EV or FCV Only, Both, Neither
  - % FCVs (of rebates)
    - 0 (n=4,967)
    - 1-5 (n=2,308)
    - 5-10 (n=45)
    - 10-50 (n=180)
    - 50+ (n=10)

Hydrogen Stations - 2/22
- ○ Planned
- ● Available
- 10-minute Service Area
- 25-minute Service Area

Results – % FCVs

Results – Access to Stations and Comparison to Other Adopters

Stations Near Tract Types

Legend:
- 50 or more (n=10)
- 10 to 50 (n=180)
- 5 to 10 (n=45)
- Less than 5 (n=2308)

DCFC (10 min): Min 12, Max 23

% FCVs Classification

Legend:
- FCVs
- BEVs
- PHEVs
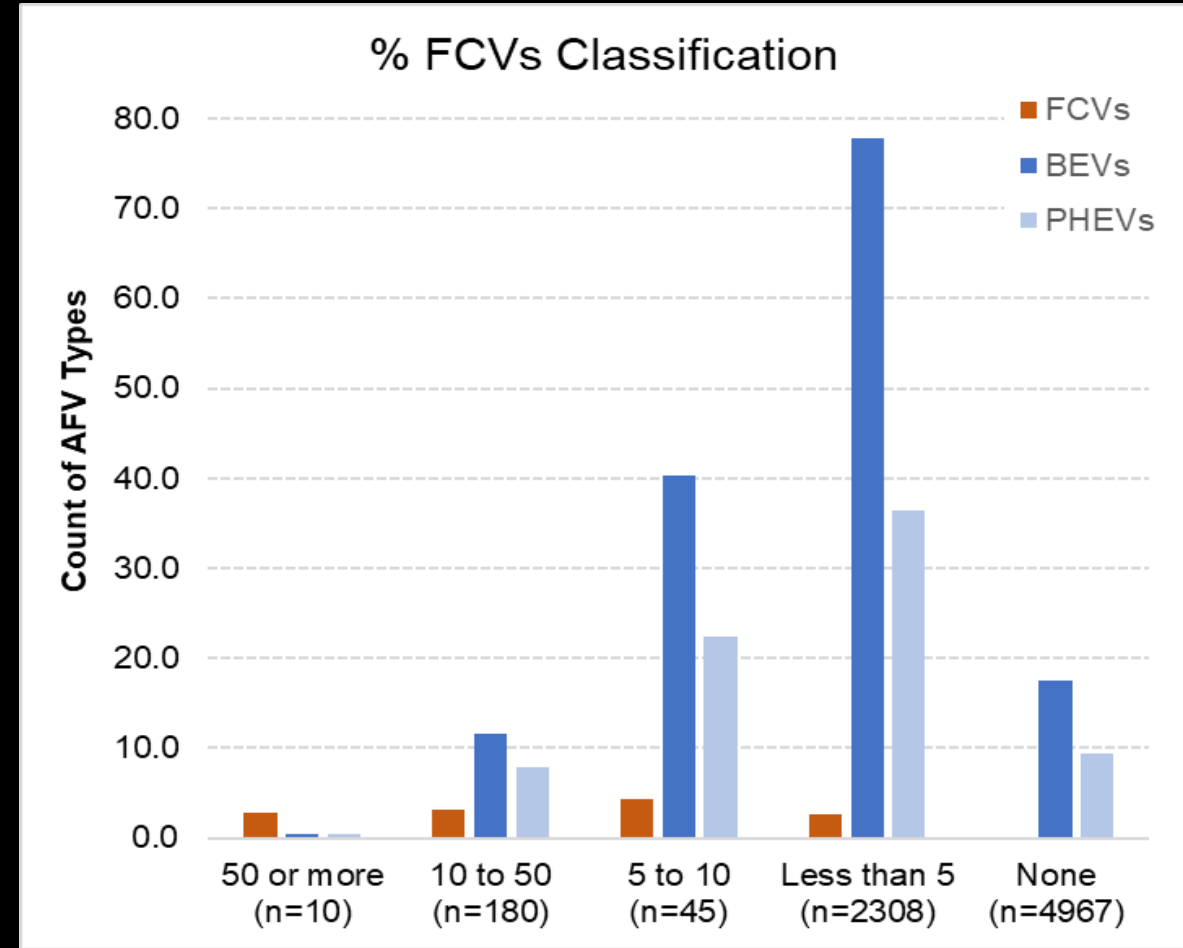
Results – Tract Differences

Tract-Level Differences, >10% FCVs as base case						
Factor	**5 to 10**		**Less Than 5**		**No FCVs**	
	β	*p*	*β*	*p*	*β*	*p*
% Bach or Higher	0.01	0.16	0.01	0.06+	-0.01	**0.02***
% 2 + Vehicles	0.02	**<0.01***	0.02	**<0.01***	-0.02	**<0.01***
% 20 min or more Commute	0.01	0.09+	0.01	0.09+	0.01	0.77
%MFH	-0.01	0.09+	-0.01	0.66	-0.01	**<0.01***
BEVs	0.06	**<0.01***	0.08	**<0.01***	0.04	**<0.01***
H2 Stations (A) within 25 min	-0.03	**<0.01***	-0.03	**<0.01***	-0.16	**<0.01***
Constant	-2.68	<0.01*	-1.71	0.01*	5.31	<0.01*

NREL Studies

EV Differences

Infrastructure

Lower
- Total BEVs
- 2+ Vehicle Ownership*
- 20 min commute

Higher
- H2 Station Availability
- Multi-Family HH

Conclusions and Next Steps

- Key findings
  - EV diffusion is far ahead
  - Areas where FCVs have seen *relatively* higher uptake compared to EVs:
    - MFH
    - Lower Comparative Income/Education Levels
    - 2+ vehicle households
  - Infrastructure Matters!
  - Higher FCVs align with higher BEVs/PHEVs

- Future Research Needs
  - Travel data
 - Stated interest in FCVs
  - Other states

Questions?
Email: scottkelley@unr.edu

Previous Work – FCV Adopters in California

Respondent Access to Stations	Los Angeles (n=62)	San Francisco (n=34)	Other (n=10)	Total (n=106)
Had Station Near Home	36 (58%)	20 (59%)	2 (20%)	58 (55%)
Had and Listed Station Near Home	35/36 (97%)	19/20 (95%)	2/2 (100%)	56/58 (97%)
Had Station on the Way	54 (87%)	31 (91%)	9 (90%)	94 (89%)
Had and Listed Station on the Way	40/54 (74%)	28/31 (90%)	9/9 (100%)	77/94 (82%)

Kelley et al. 2022
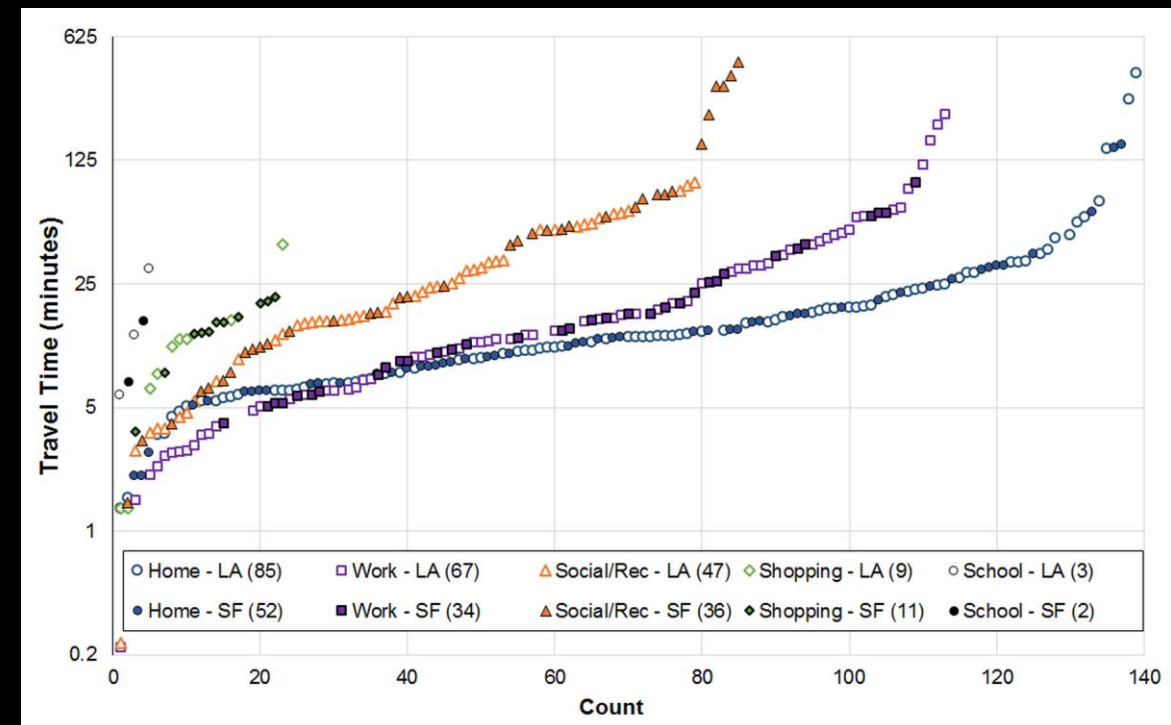
Kelley et al. 2020

Results – FCVs vs EVs