UCLA Luskin Center for Innovation

Informing effective and equitable environmental policy

An Analysis of California Electric Vehicle Incentive Distribution and Vehicle Registration Rates Since 2015

IS CALIFORNIA ACHIEVING AN EQUITABLE CLEAN VEHICLE TRANSITION?

BY RACHEL CONNOLLY, DANIEL COFFEE, AND GREGORY PIERCE

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CONTENTS

TERMS AND DEFINITIONS

AB	Assembly Bill
ACC	Advanced Clean Cars
ACS	American Community Survey
AQMD	Air quality management district
BEV	Battery electric vehicle
CARB	California Air Resources Board
CC4A	Clean Cars 4 All
CCFR	California Clean Fuel Reward
CES	CalEnviroScreen (California Communities Environmental Health Screening Tool)
CVAP	Clean Vehicle Assistance Program
CVRP	Clean Vehicle Rebate Project
DAC	Disadvantaged community
DCAP	Driving Clean Assistance Program
DCSJ-RP	Drive Clean in the San Joaquin Rebate Program
EMFAC	EMission FACtor emissions model and database, maintained by CARB
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
ICEV	Internal combustion engine vehicle
IRA	Inflation Reduction Act
LCFS	Low-carbon fuel standard
OEHHA	California Office of Environmental Health Hazard Assessment
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid electric vehicle
Residential Vehicles	Vehicle classes typically owned by households
SB	Senate Bill
SCE-PreOR	Southern California Edison Pre-Owned EV Rebate Program
SJVAPCD	San Joaquin Valley Air Pollution Control District
ZEV	Zero-emission vehicle

EXECUTIVE SUMMARY

California is a national leader in promoting electric vehicle (EV) adoption. It maintains ambitious targets for light- and heavy-duty fleet turnover, including a mandate requiring that all passenger vehicles sold in the state be zero-emission by 2035. In support of these goals, the state has long operated several light-duty clean vehicle incentive programs that provide financial support for households to purchase a new electric vehicle, often by replacing an older internal combustion engine vehicle (ICEV). This suite of programs includes the Clean Vehicle Rebate Project (CVRP) as well as several more recently developed equity-focused opportunities, such as Clean Cars for All (CC4A), which limit participation to low- and moderate-income households. These programs targeting low-income populations can help ensure no populations are left behind and will support a just transition to clean energy.

This report considers the distributional impacts of these programs, especially for equity. We assess six programs: three statewide – CVRP, the Clean Vehicle Assistance Program (CVAP), and the California Clean Fuel Reward (CCFR) – and three regional – CC4A, Drive Clean in the San Joaquin Rebate Program (DCSJ-RP), and the Southern California Edison Pre-Owned EV Rebate Program (SCE-PreOR). We not only evaluate the effectiveness of incentives in benefiting California's disadvantaged populations, but also characterize the potential impact these incentives have on electric vehicle uptake rates throughout the state. The researchers use data sources about vehicle fleet characterization, distribution of incentive funds, and measures of socioeconomic and environmental burden in communities across California.

We first examined the total dollars distributed by the six aforementioned clean vehicle incentive programs. Since 2010, more than $1.9 billion has been allocated through the programs via nearly 1 million individual incentive awards. Nearly 128,000 awards (approximately $314 million) were distributed to households in disadvantaged communities (DACs) as defined by Senate Bill 535 (2012).

We find, as suggested by previous research, that CVRP (by far the largest program historically) is heavily skewed towards benefitting non-DAC tracts, with only 12.1% of its funds distributed to recipients in DAC tracts throughout the lifetime of the program. We found similar results for the two other statewide programs, CVAP and CCFR. In comparison, the three regional programs – CC4A, DCSJ-RP, and SCE-PreOR – have been more effective at delivering funds to DAC and lower-income tracts (e.g., 52% of funds distributed within DAC tracts for CC4A).

We next analyzed the progression of non-internal combustion engine vehicle (non-ICEV, including battery electric vehicles, plug-in hybrids, and fuel cell electric vehicles) adoption by Californians from 2015 to 2021 as a percentage of census tract-level residential vehicle registrations. In that time frame, nearly every region of the state has seen an increased registration share of non-ICEVs. However, clean vehicle registration rates in some areas – such as rural areas and the Los Angeles core – remain persistently low.

In addition to spatial inequalities, a more granular examination of adoption by census tract-level median income shows disproportionately low adoption among lower-income tracts, with the greatest growth in middle- and upper-middle-income tracts (median incomes of $75,000 to $149,999). Absolute penetration rates also remain relatively low compared to the state's goals, with non-ICEVs accounting for more than 10% of residential vehicle registrations in only a handful of tracts.

When further examining tract-level non-ICEV adoption versus measures of socioeconomic and environmental disadvantage, we find clear and consistent patterns of the adoption of clean vehicles in DAC tracts lagging behind adoption in less burdened and more affluent tracts. In all years from 2015 to 2021, non-ICEV registration rates in DAC census tracts were approximately one-third of rates in non-DAC tracts. While the proportional disparity between DACs and non-DACs has narrowed very slightly over time, the absolute registration rate gap has widened.

We also projected non-ICEV ownership rates to 2035 using both the status quo of current rates, as well as optimistic scenarios. While these scenarios are all assumption-laden, even in the most optimistic cases, it appears that California's most marginalized communities will remain far behind in clean vehicle access, with non-ICEV registration rates in the mid-20s (%). The lack of affordable EVs available in the near term further underlines the uphill battle in the pursuit of EV adoption equity.

Given these challenges, we recommend several policy interventions to help California meet its goals. First, the state must allocate more funding for more narrowly constructed EV equity programs to have a shot at reaching 2035 targets. One idea for implementation is to offer revolving loan funds to leverage limited public dollars more effectively. Additionally, program administrators must be creative in maximizing the used vehicle inventory for incentive programs, as well as improving charging infrastructure in DACs and low-income communities. Finally, state-sponsored one-stop shop platforms for incentive access must be re-focused on delivering savings and climate-resilient infrastructure rather than merely advertising benefits. These actions and more are necessary to achieve the state's impending light-duty fleet targets and provide comprehensive services for those most in need.

1. BACKGROUND AND MOTIVATION

California is a national leader in the electric vehicle (EV) space, with ambitious targets for light- and heavy-duty fleet turnover, including a mandate requiring that all passenger vehicles sold in the state are zero-emission by 2035. In support of these goals, the state has operated several longstanding light-duty clean vehicle incentive programs providing financial support for households to purchase a new electric vehicle, often by replacing an older internal combustion engine vehicle (ICEV). This suite of programs includes several equity-focused opportunities, which limit participation to low- and moderate-income households.

Clean vehicle transportation initiatives in California have operated since 2010. The Clean Vehicle Rebate Project (CVRP), a recently closed program (funding expired in late 2023), distributed rebates for the purchase or lease of new zero-emission or plug-in hybrid vehicles meeting program criteria. Since 2015, Clean Cars 4 All (CC4A), a low- and moderate-income vehicle replacement program, is currently expanding statewide. A limited number of studies have assessed the distributional equity impacts of these existing clean vehicle incentive and rebate programs. Largely, scholars have found that CVRP rebates have not been equally distributed to low-income populations and communities of color (Guo & Kontou, 2021; Hennessy & Syal, 2023; Ju et al., 2020; Rubin & St-Louis, 2016), and in comparison of CVRP to CC4A, results demonstrate that CC4A benefit distribution has been significantly positively associated with increased vulnerability and disadvantage as measured by various metrics, including California Senate Bill (SB) 535 (2012) disadvantaged community (DAC) status (Ju et al., 2020). Additionally, there are several smaller clean vehicle equity programs also operating in the state, along with CVRP and CC4A, that have not yet been formally incorporated into the previously described evaluation efforts.

Since it has been more than 10 years since the proliferation of these clean vehicle incentive programs, it is time to take stock and assess not only the distributive impacts of such programs and the effectiveness of incentives in benefiting California's disadvantaged populations, but also characterize the potential impact these incentives have on electric vehicle uptake rates throughout the state. One recent study compared vehicle registration alongside CVRP rebate distribution and found greater disparities in rebate allocation than in EV penetration, but they did not include any of the other equity-focused programs in their analysis (Hennessy & Syal, 2023). Such a knowledge gap is especially important to fill since we are only a decade out from the 2035 targets, and several statewide programs have shut down (CVRP) or are facing substantial challenges (Low Carbon Fuel Standard [LCFS]).

At the same time, federal incentives for clean vehicle uptake are beginning to proliferate through funding streams such as the Inflation Reduction Act of 2022 (IRA) but are still in relatively early stages. This presents an opportunity to apply lessons learned from longstanding California programs to ensure equity in clean vehicle uptake and support a just transition to clean energy nationwide.

We have previously analyzed the implementation and associated equity implications of several clean vehicle incentive programs, including evaluating the early and more recent stages of the CC4A program through stakeholder and participant interviews and publicly available data (Pierce et al., 2021; Pierce & DeShazo, 2017), as well as potential one-stop shop opportunities for program participants to enroll in multiple programs close-to-simultaneously, including EV purchase programs (Pierce & Connolly, 2020).

However, to our knowledge, no previous research has evaluated the distributive equity impacts of the full suite of clean vehicle incentive programs at a spatially resolved level or characterized the quantitative relationship between these programs and EV registration levels systematically, which is our main objective in this study.

2. DATA AND METHODS

This study relies on a variety of data sources pertaining to vehicle fleet characterization in the state of California, distribution of funds through clean vehicle incentive programs, and measures of socioeconomic and environmental burden in communities.

Vehicle registration data is provided by the California Air Resources Board's (CARB's) EMission FACtor (EMFAC) fleet database. EMFAC maintains a database of annual vehicle registrations in the State of California by vehicle class (e.g., passenger cars) and fuel type and technology (e.g., gasoline and plug-in hybrid electric vehicles [PHEV]) at the census block group level. The registration data in the EMFAC fleet database are provided by the California Department of Motor Vehicles.

For our purposes, we confined our analysis to residential vehicles – classes typically owned by households. The EMFAC classification nomenclature includes passenger cars, type 1 and type 2 light-duty trucks, and motorcycles. We aggregated block group-level totals to the census tract level, providing a residential vehicle fleet estimate for each tract. We calculated the total number of non-internal combustion engine (non-ICEV) vehicles, which includes any fuel technologies besides ICEV, including PHEVs.[1] Non-ICEV fleet totals are the focus of analysis in this study.

Starting in 2019, the EMFAC database shifted from utilizing 2010 census block groups to 2020 census block groups. Therefore, we transformed the data for 2019-2021 using the National Historical Geographic Information System crosswalk file for converting data for 2020 block groups to 2010 block groups (Manson et al., 2023). EMFAC block group fleet totals for 2019-2021 were disaggregated among component 2010 block groups, weighted by the number of households. Of the available weights in the crosswalk file, households were chosen as most likely to correlate best with a number of vehicles. The total number of vehicles estimated was rounded to the nearest integer, reflecting the fact that fractions of a vehicle cannot be registered in a given census tract.

Following the data transformation, 2019-2021 fleet block group totals were aggregated within their corresponding 2010 census tracts to align with available incentive programs and sociodemographic data.

Clean vehicle incentive data was incorporated from six different programs operating in California over varying periods. An overview of the programs is provided in Table A-1. Three of the programs – CVRP, the Clean Vehicle Assistance Program (CVAP), and the California Clean Fuel Reward (CCFR) – are (or were) accessible statewide. The remaining three – CC4A, the Drive Clean in the San Joaquin Rebate Program (DCSJ-RP), and the Southern California Edison Pre-Owned EV Rebate Program (SCE-PreOR) – are regional programs. CC4A has historically been administered by four of the state's AQMDs: Bay Area AQMD, Sacramento Metropolitan AQMD, San Joaquin Valley Air Pollution Control District (SJVAPCD), and South Coast AQMD.

1 Our definition of non-ICEV aligns with the term EV as well as the definition of zero-emission vehicle (ZEV) used by CARB under Advanced Clean Cars (ACC) regulations. CARB classifies clean plug-in hybrid vehicles within ZEVs.

The San Diego County Air Pollution Control District has recently begun administering CC4A within its jurisdiction, but too recently for data from its efforts to be incorporated into this analysis. DCSJ-RP is administered by SJVAPCD within its administrative boundary.

All incentive datasets are at the participant level, providing records of each instance in which funds were distributed to support a clean vehicle purchase. This includes the dollar value of each reward, the date, and the census tract in which the recipient resides. For CVRP and CC4A, these records are publicly available; participant-level data for CCFR, SCE-PreOR, CVAP, and DCSJ-RP were provided by Southern California Edison, CARB, and SJVAPCD upon request.

For *population characterization data* on socioeconomic and environmental burden, we rely on public datasets made available by the California Office of Environmental Health Hazard Assessment (OEHHA) and the U.S. Census Bureau. OEHHA publishes the California Communities Environmental Health Screening Tool (CalEnviroScreen, or CES), currently in version 4.0. CES is the nation's oldest and most refined geographic environmental screening tool, characterizing the environmental and socioeconomic burden of communities based on numerous environmental, public health, and socioeconomic indicators. In our analysis, we primarily rely on the census tract-level percentile for communities, which places all census tracts in California on a relative scale from 0-100 based on their absolute burden score; the highest-percentile tracts are those facing the highest overall levels of environmental, public health, and socioeconomic challenge.

We also utilize OEHHA's designation of California communities statutorily defined as disadvantaged under SB 535, last updated May 2022. The primary determinant of a community's disadvantaged status is its presence within the 75th percentile of CES scores. It also includes tracts previously identified as disadvantaged, those lacking sufficient CES data to receive a score but with high levels of pollution, and Tribal lands.

To assess the general economic health of communities, we rely on census tract-level median income figures from the American Community Survey (ACS) 2019 5-year averages – the most recent 5-year average dataset available – from the U.S. Census Bureau.

From these disparate sources, we assembled a consolidated dataset for the >8,000 California 2010 census tracts that incorporates:

- CES 4.0 percentile
- Binary variable for a tract's SB 535 DAC status and presence within a CC4A administering AQMD
- Median income
- Total dollars distributed, by year and in total, for each clean vehicle incentive program
- Total vehicle purchases supported, by year and in total, for each clean vehicle incentive program

Using this consolidated dataset, we assessed patterns of program activity and non-ICEV adoption across the state concerning measures of environmental and socioeconomic (dis) advantage, as well as geography. We also use these data to develop pairwise Pearson correlations to observe the relationship between incentive distribution and non-ICEV registration at the census tract level.

To gauge California's non-ICEV adoption trajectory, we created three sets of projections for statewide non-ICEV registration rates. These projections examine aggregate registration rates for the 95th and 90th percentile CES score census tracts, DAC tracts below 90th percentile CES score, non-DAC tracts, and the entire state. The three projections and respective methods entailed were:

- *Conservative Projection*: Based on 2015-2021 EMFAC data, we calculated the average year-over-year delta [change] values for the number of registered residential vehicles, the number of non-ICEVs, and the percent of registrations that are non-ICEVs for each census tract. Assuming these values reflect linear trends for each tract, we project residential vehicle fleet size and two different values for a number of non-ICEVs (based on delta values for the number and percent of fleets) for 2026, 2030, and 2035. We ensure that no impossible tract-level outcomes arise (e.g., a negative number of residential vehicles, non-ICEV registrations that exceed residential vehicle registrations), then take the lower of the two non-ICEV estimates.
- *Optimistic Projection*: We use the same methods as the conservative projection above, with two key differences. Average year-over-year delta values were calculated based only on the two most recent year-over-year changes (EMFAC 2019-2020 and 2020-2021), and we took the higher of the two non-ICEV estimates for each tract for each year.
- *Goal-Meeting Projections*: To showcase the gap between the prior projections and the state's clean vehicle adoption goals, we created a set of projections that assume the statewide non-ICEV registration rate will reach 50% in 2050. To do so, we first calculate the ratio of % non-ICEV registrations for the four subsets of tracts to the entire state for 2021 (based on EMFAC data), 2026, 2030, and 2035 (based on the optimistic projection above), and 2050 (based on a least-squares linear trend of the prior four data points). We then calculated the average annual delta in relative % non-ICEV registrations for the four subsets compared to the statewide registration rate, reflecting how proportional registration in the subgroup tracts changes compared to the statewide average over time.

We create three scenarios, each of which assumes an identical, linear progression of the statewide non-ICEV registration rate from its real-world rate in 2021 (3.2%) to the goal rate in 2050 (50%). Non-ICEV registration rates for the three subgroups of DAC tracts were calculated based on the ratio estimates calculated prior, with the second and third scenarios doubling and tripling these relative values, respectively. In these scenarios, DAC tracts approach parity with the statewide average more quickly. We then backwards-calculate the requisite non-ICEV registration rate in non-DAC tracts to meet the overall statewide goal of 50% in 2050, assuming that residential vehicle fleet weights among the subgroups remain identical to 2021.

The results of these projections are included in the *Looking Forward: Ways to Project California's Non-ICEV Growth* section within the *Results*.

Geographic mapping of vehicle registration and program funding data was done in ArcGIS Pro, joining our consolidated dataset to the CES 4.0 shapefile (published by OEHHA) by census tract.

3. RESULTS

3.1. Clean Vehicle Incentive Program Activity

We examined the total dollars distributed by the six clean vehicle incentive programs over their lifetimes (Table 1, Figure 1). Since 2010, more than $1.9 billion has been allocated through all six programs we examined, with nearly 128,000 program incentives (accounting for approximately $314 million) distributed to DACs, out of a total of approximately 964,500 incentives.[2]

CVRP dwarfs the other programs examined in terms of funding magnitude, accounting for nearly half of the aggregate total of funds delivered within DAC tracts ($154 million of $314 million total) and over two-thirds of funds within non-DAC tracts ($1.12 billion of $1.6 billion total). These totals demonstrate that CVRP is heavily skewed towards benefitting non-DAC tracts, with only 12.1% of its lifetime funds going to recipients in DAC tracts (see Figure A-1). Because of CVRP's outsized role as the state's flagship clean vehicle incentive program, this inequity weighs heavily on the overall distribution of funds between DACs and non-DACs. Moreover, CVRP beneficiaries tend to live in more affluent communities, based on a weighted average of tract median income; this trend aligns with findings from existing peer-reviewed scholarship (Guo & Kontou, 2021; Hennessy & Syal, 2023; Ju et al., 2020; Rubin & St-Louis, 2016).

TABLE 1

Funds distributed and number of vehicles supported by six clean vehicle incentive programs in California over indicated periods, by census tract SB 535 disadvantaged community (DAC) status, with tract-level income.

		Statewide Programs			Regional Programs		
	Total *(6 programs)*	**CVRP** *(2010-2023)*	**CVAP** *(2018-2023)*	**CCFR** *(2020-2023)*	**CC4A** *(2015-Q2 2023)*	**DCSJ-RP** *(2015-Early 2024)*	**SCE-PreOR** *(2021-Early 2024)*
Funding to DACs	$314 million	$154 million	$6.1 million	$50.6 million	$73.4 million	$26.6 million	$3.1 million
Funding to Non-DACs	$1.6 billion	$1.12 billion	$18.9 million	$367 million	$68.7 million	$30.9 million	$5.6 million
Percent of funding to DACs	16.4%	12.1%	24.5%	12.1%	51.7%	46.3%	35.8%
Vehicles in DACs (# of incentives)	127,769	59,593	1,227	47,532	8,984	9,121	1,312
Percent of Vehicles in DACs	13.3%	11.1%	24.5%	12.3%	51.5%	45.9%	52.3%
Median census tract-level income	$111,000	$112,000	$85,000	$112,000	$68,000	$88,000	$65,000

Notes: Income from ACS 2019 5-year averages (US Census Bureau, 2019). Median income is a weighted average by funding, rounded to the nearest thousand.

2 These estimates do not represent the exact number of incentive recipients, since some individuals have stacked incentives, receiving more than one from different programs.

The other two statewide programs examined – CCFR and CVAP – exhibit similar trends. CCFR is nearly identical to CVRP concerning the portion of its funding delivered within DAC tracts and the weighted median income of recipient tracts. CVAP is somewhat more progressive in its outcomes, delivering 24.5% of its funds to DACs with a weighted median tract income of $85,000. However, CVAP's impact is limited by its small funding magnitude, having delivered only $25 million from 2018 to 2023.

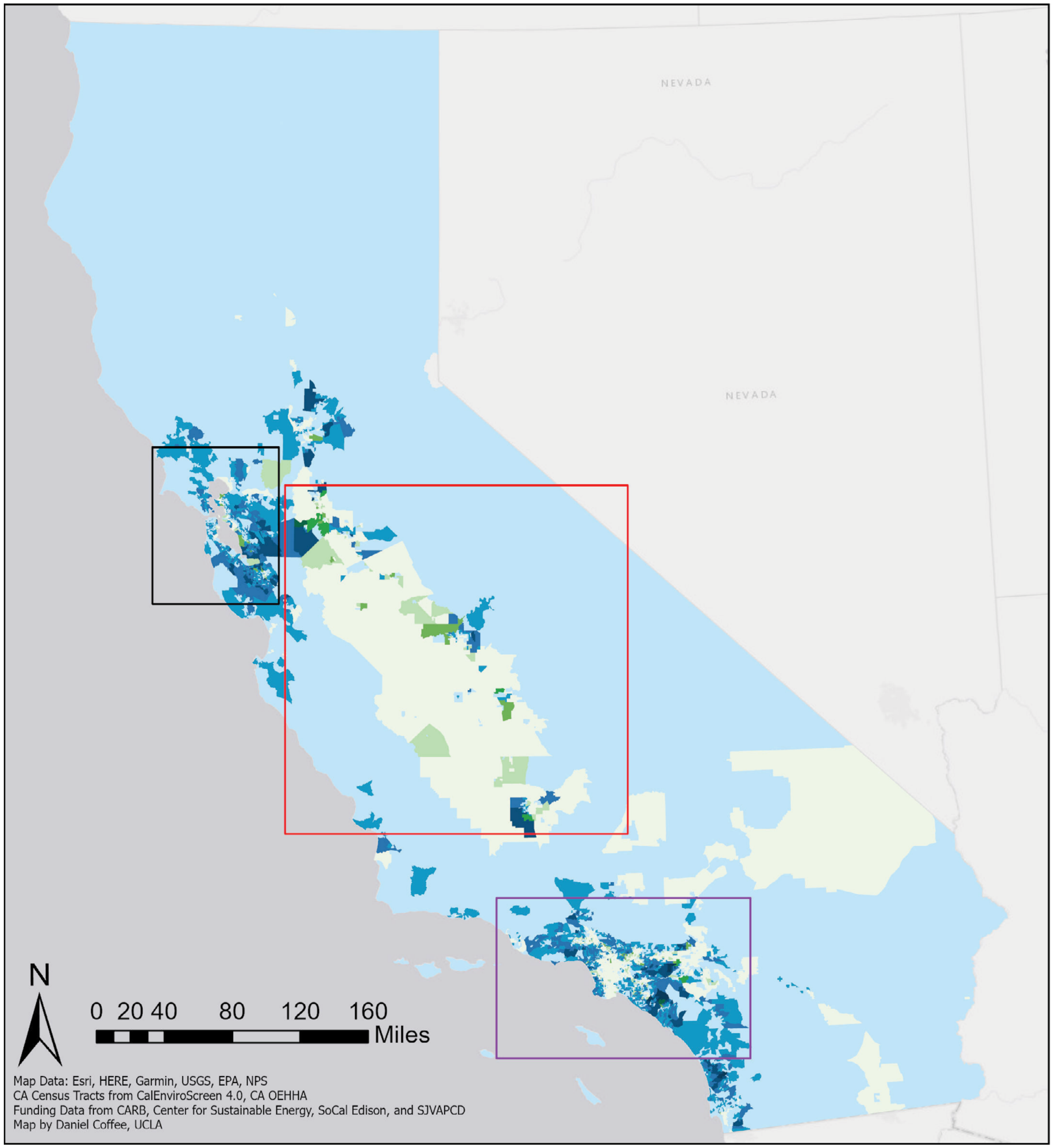
In comparison, the three regional programs – CC4A, operated by four of the state's AQMDs; DCSJ-RP, operated by SJVAPCD; and SCE-PreOR, operated by Southern California Edison – have been much more effective at delivering funds to DAC and lower-income tracts. As of Q2 2023, CC4A (Figure 2) has delivered over 51% of its funds to recipients in DAC tracts, with DCSJ-RP close behind at approximately 46% and SCE-PreOR at 36%; the distribution of CC4A funding to DACs also varies by regional AQMDs, see (Pierce et al., 2021) and Figure 2. The weighted median income of tracts receiving CC4A funds (approximately $68,000) is also significantly lower than for the statewide programs.

When assessing the programs based on the number of vehicles supported (i.e., individual instances of participation, such as receipt of a rebate), the portion of activity within DACs and the income of tracts largely match the above results based on funding levels. However, it is notable that the overall portion of activity within DACs is three percentage points lower than overall funding levels (13.3% versus 16.4%, respectively). This is likely attributable, in large part, to CVRP's lower activity level in DACs compared to funding levels (11.1% versus 12.1%, respectively) and suggests that although fewer DAC residents are benefitting from CVRP, those that do are receiving greater amounts of financial assistance than non-DAC residents, on average, due to the increased rebate levels offered for low- and moderate-income households.

However, the dominant size of CVRP and CCFR in funding terms means that overall statewide performance is lackluster despite the relative success of regional programs. Overall, only 16% of funds across the six programs have been delivered within DACs. When we examine the geographic distribution of funds (Figure 1), concentrated areas of heavy funding can be observed in non-DAC tracts in the San Francisco Bay and Los Angeles areas, as well as (to a lesser extent) in the San Diego area. A small number of DAC tracts are among those receiving the highest levels of funding, and the vast majority of DACs have received less than $250,000 across all six programs to date. A notable pattern can also be observed in urban cores with many DAC tracts receiving very low levels of funding while being surrounded by well-funded, non-DAC suburbs. This pattern is best exemplified in and around the City of Los Angeles and (to a lesser extent) in the East Bay Area.

FIGURE 1 (PART 1)

Total administered clean vehicle incentive funds across six programs, census tract level, 2010 to present, by SB 535 DAC status.*



Funds in Non-SB 535 DAC Tracts

- $250,000 or less
- $250,001 to $500,000
- $500,001 to $1 million
- $1,000,001 to $3 million
- Greater than $3 million

Funds in SB 535 DAC Tracts

- $250,000 or less
- $250,001 to $500,000
- $500,001 to $1 million
- $1,000,001 to $3 million
- Greater than $3 million

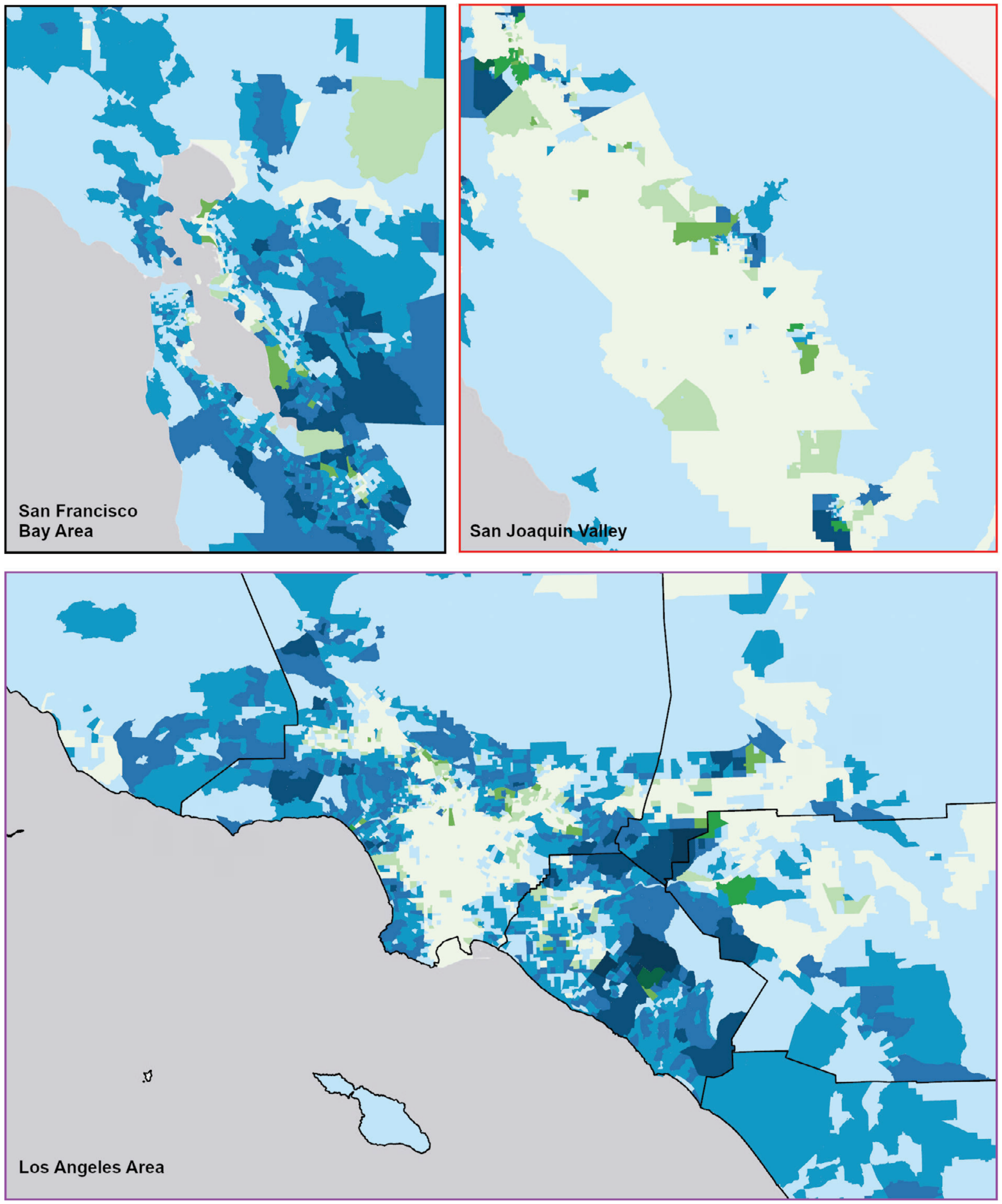
*Programs and Funding Data Periods

Clean Vehicle Rebate Project	2010-2023
Clean Cars 4 All	2015-Q2, 2023
Clean Vehicle Assistance Program	2018-2023
California Clean Fuel Reward	2020-2023
Drive Clean in the San Joaquin - Rebate Program	2015-Early 2024
Southern California Edison Pre-Owned EV Rebate Program	2021-Early 2024

*Aggregate funding brackets are classified manually.

FIGURE 1 (PART 2)

Total administered clean vehicle incentive funds across six programs, census tract level, 2010 to present, by SB 535 DAC status.*



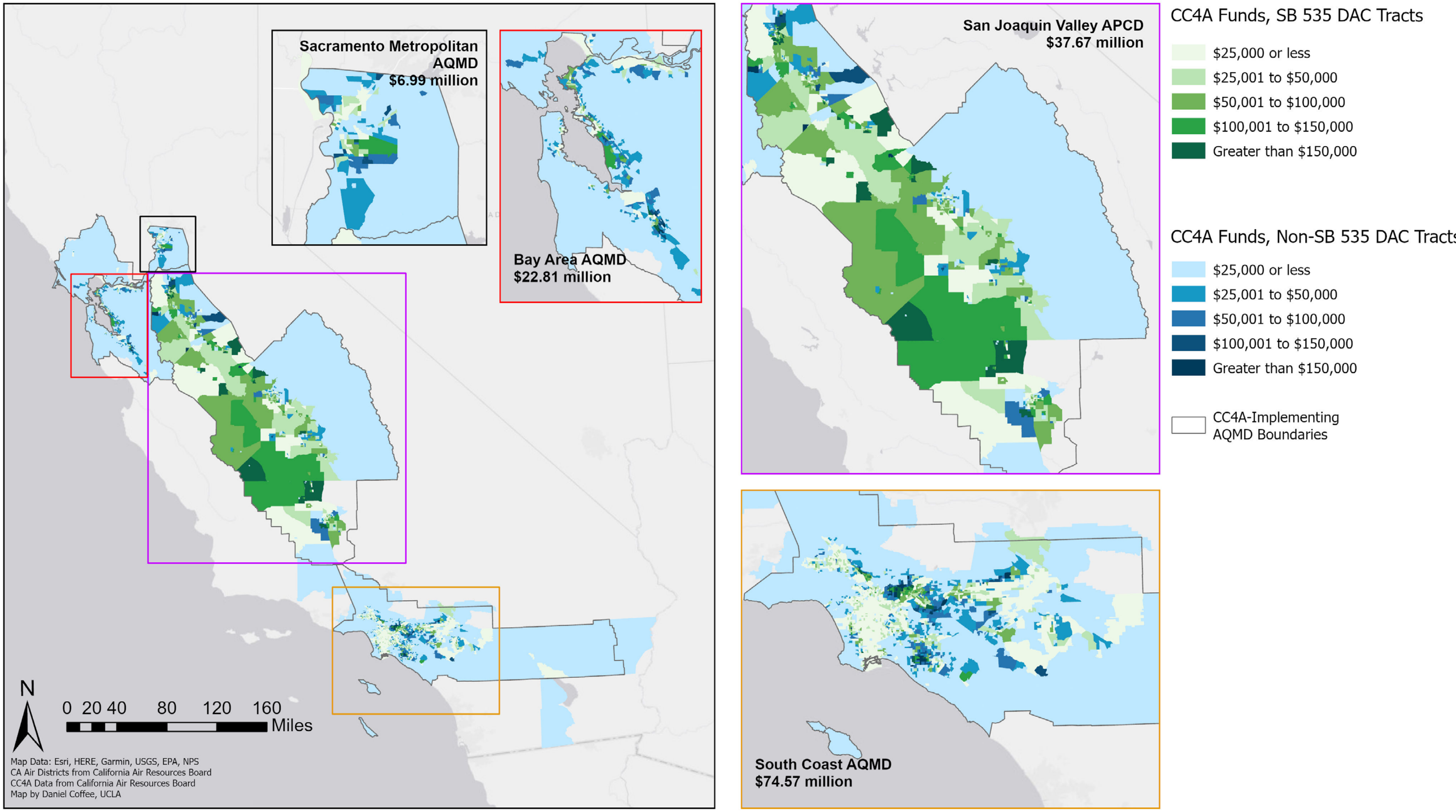
*Programs and Funding Data Periods

Clean Vehicle Rebate Project	2010-2023
Clean Cars 4 All	2015-Q2, 2023
Clean Vehicle Assistance Program	2018-2023
California Clean Fuel Reward	2020-2023
Drive Clean in the San Joaquin - Rebate Program	2015-Early 2024
Southern California Edison Pre-Owned EV Rebate Program	2021-Early 2024

*Aggregate funding brackets are classified manually.

FIGURE 2

Total administered CC4A funding, census tract level, and by administering AQMD, 2015 to Q2 2023, by SB 535 DAC Status.*



*Aggregate funding brackets are classified manually.

TABLE 2

Characterization of census tracts not served by six clean vehicle incentive programs in California by SB 535 DAC status, median income (to nearest hundred), and CalEnviroScreen 4.0 percentile.

	Statewide Programs			Regional Programs		
	CVRP *(2010-2023)*	CVAP *(2018-2023)*	CCFR *(2020-2023)*	CC4A *(2015-Q2 2023)*	DCSJ-RP *(2015-Early 2024)*	SCE-PreOR *(2021-Early 2024)*
% DAC among non-receiving tracts	36.5%	30.5%	35.6%	15.1%	71.4%	21.4%
Median Income in non-receiving tracts	$29,200	$70,300	$37,200	$95,200	$35,500	$86,700
Mean CES 4.0 Percentile of non-receiving tracts	68%	50%	66%	37%	83%	47%

Conversely, when examining CC4A in isolation we observe many more DAC tracts at the highest levels of funding. We also see fewer examples of high concentrations of funds being delivered to non-DAC tracts, though some instances are present, especially in and around Los Angeles, Riverside, and San Jose.

Using another analytical lens, we characterized the tracts with no funding recipients for each program (Table 2). Among the statewide programs, DACs account for approximately one-third of non-receiving tracts – a slightly disproportionate overrepresentation. CES percentiles of these tracts tend to be high (in the top half or top third of tracts). Income is less conclusive but among the two largest programs in terms of expenditures (CVRP and CCFR), the median income among non-receiving tracts is very low (Table 2).

In contrast, tracts not receiving funds from CC4A are much more likely to be non-DACs, as DACs account for only 15.1% of non-receiving tracts. Similarly, non-receiving tracts are generally higher income and have relatively low levels of environmental and socioeconomic burden, per CES. This further reinforces the finding that CC4A has been significantly more effective than other programs at prioritizing funds towards lower-income and highly burdened tracts.

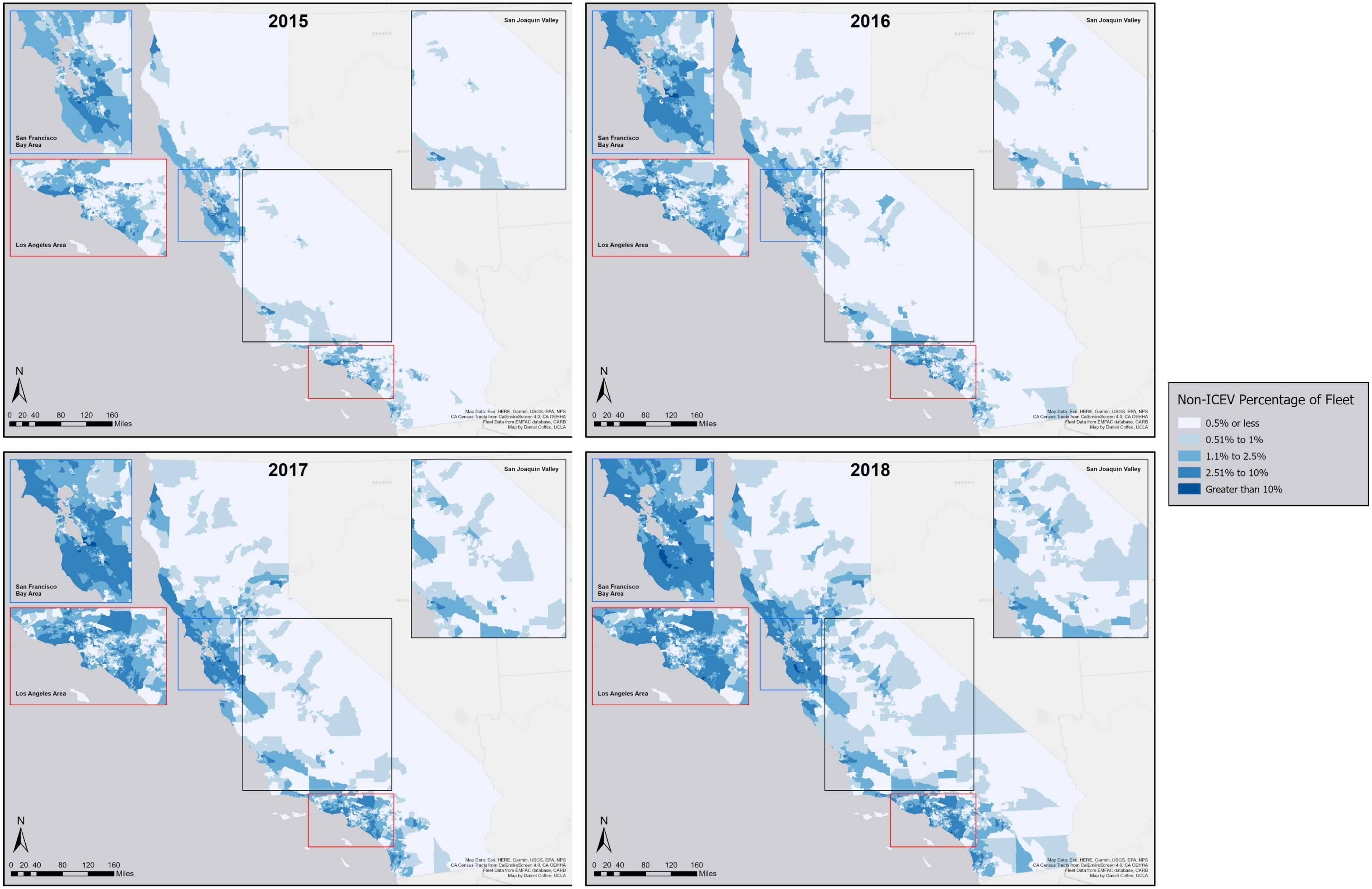
While the characteristics of non-receiving tracts for DCSJ-RP appear superficially inequitable, it is difficult to disentangle these observations from the fact that the SJVAPCD's administrative area contains a high proportion of DAC or other priority tracts.

3.2. Vehicle Registrations

Figure 3 shows the progression of non-ICEV adoption by Californians from 2015 to 2021 as a percentage of tract-level residential vehicle registrations. In that time frame, nearly every part of the state has seen an increased registration share of non-ICEVs, though some areas – such as rural parts of the state and the Los Angeles core – remain persistently low. Moreover, patterns of relative distribution remain more or less unchanged from 2015 to 2021, with the highest areas of penetration concentrated in the state's major metropolitan areas: the San Francisco Bay, Los Angeles, and San Diego areas. Absolute penetration rates also remain fairly low in comparison to the state's adoption goals, with non-ICEVs accounting for more than 10% of residential vehicle registrations in only a handful of tracts.

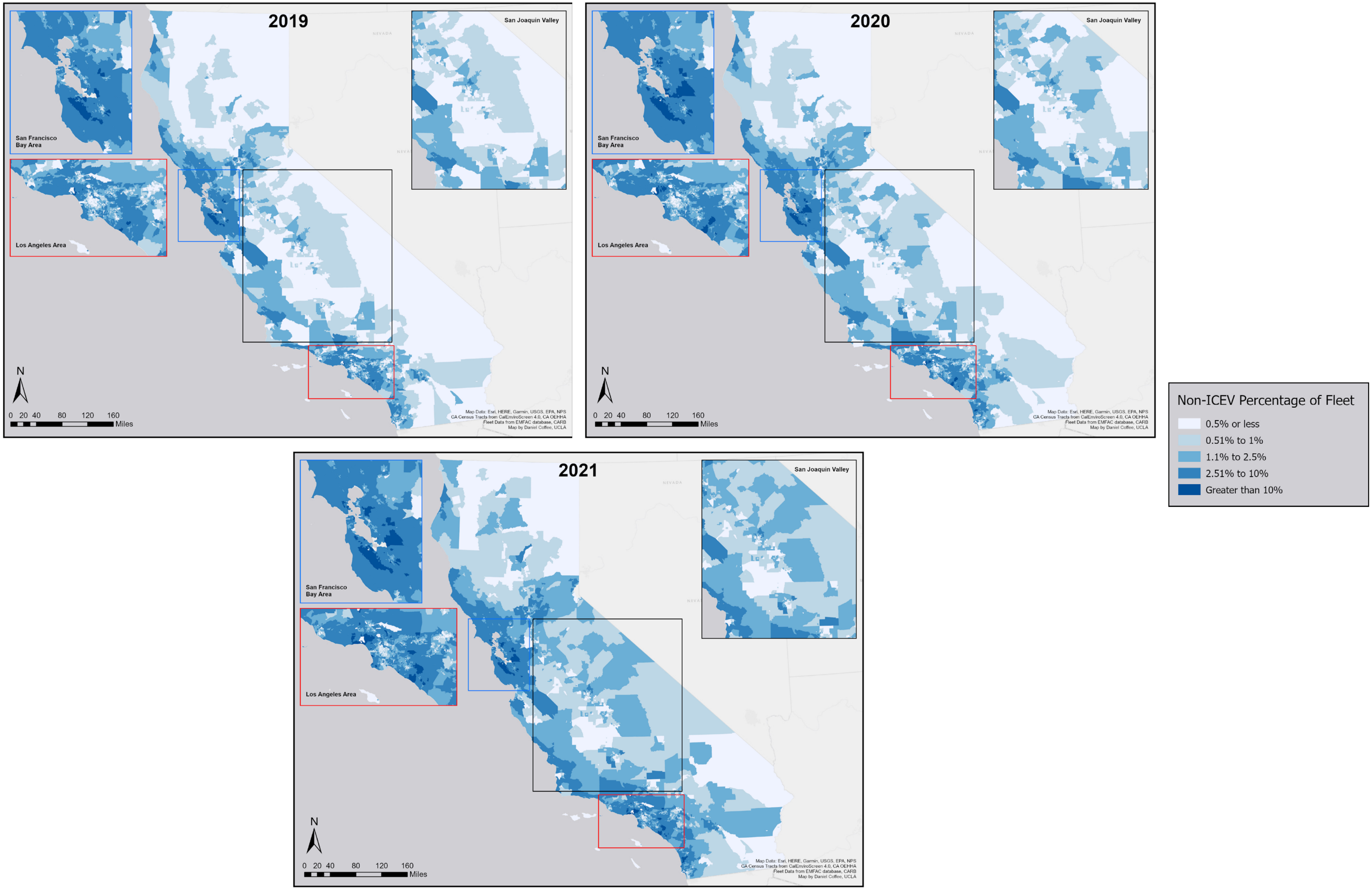
FIGURE 3

Penetration of non-ICEVs in California as a percentage of residential vehicle registrations, census tract level, 2015-2021.*



*Non-ICEV registration rate brackets classified manually.

Penetration of non-ICEVs in California as a percentage of residential vehicle registrations, census tract level, 2015-2021.*



*Non-ICEV registration rate brackets classified manually.

When assessing tract-level non-ICEV adoption versus measures of socioeconomic and environmental disadvantage, we find clear and consistent patterns of disadvantaged communities lagging behind less burdened and more affluent ones. In all years from 2015 to 2021, non-ICEV registration rates in SB 535 DAC census tracts were approximately one-third of rates in non-DAC tracts (Table 3). The proportional disparity between DACs and non-DACs has narrowed slightly over time, but the absolute registration rate gap has widened.

A more granular examination of adoption by tract-level median income (Figure 4) shows disproportionately low adoption among lower-income tracts, with the greatest growth in middle- and upper-middle-income tracts (median incomes of $75,000 to $149,999). Gains are also disproportionately high among the small number of high-income tracts.

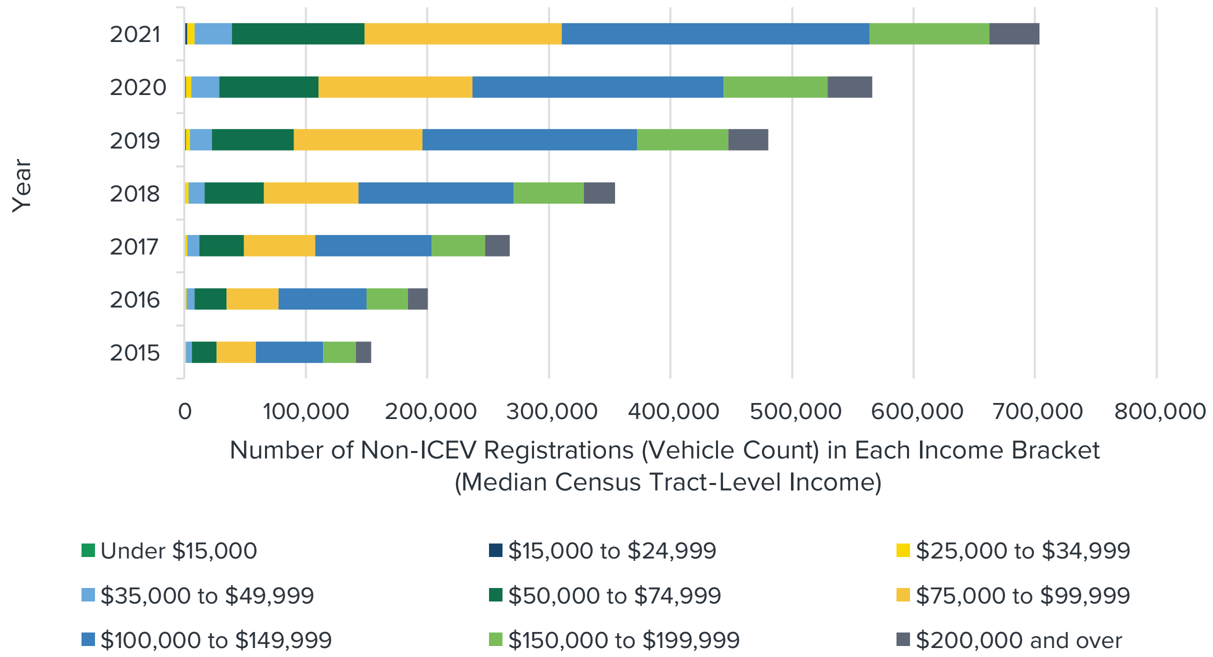
TABLE 3

Percent of residential vehicle registrations that are non-ICEVs in California, by year and SB 535 DAC status.

	Percent non-ICEV registrations						
SB 535 DAC Status	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Yes	0.27%	0.36%	0.50%	0.65%	0.91%	1.06%	1.39%
No	0.92%	1.20%	1.59%	2.11%	2.74%	3.10%	3.82%

FIGURE 4

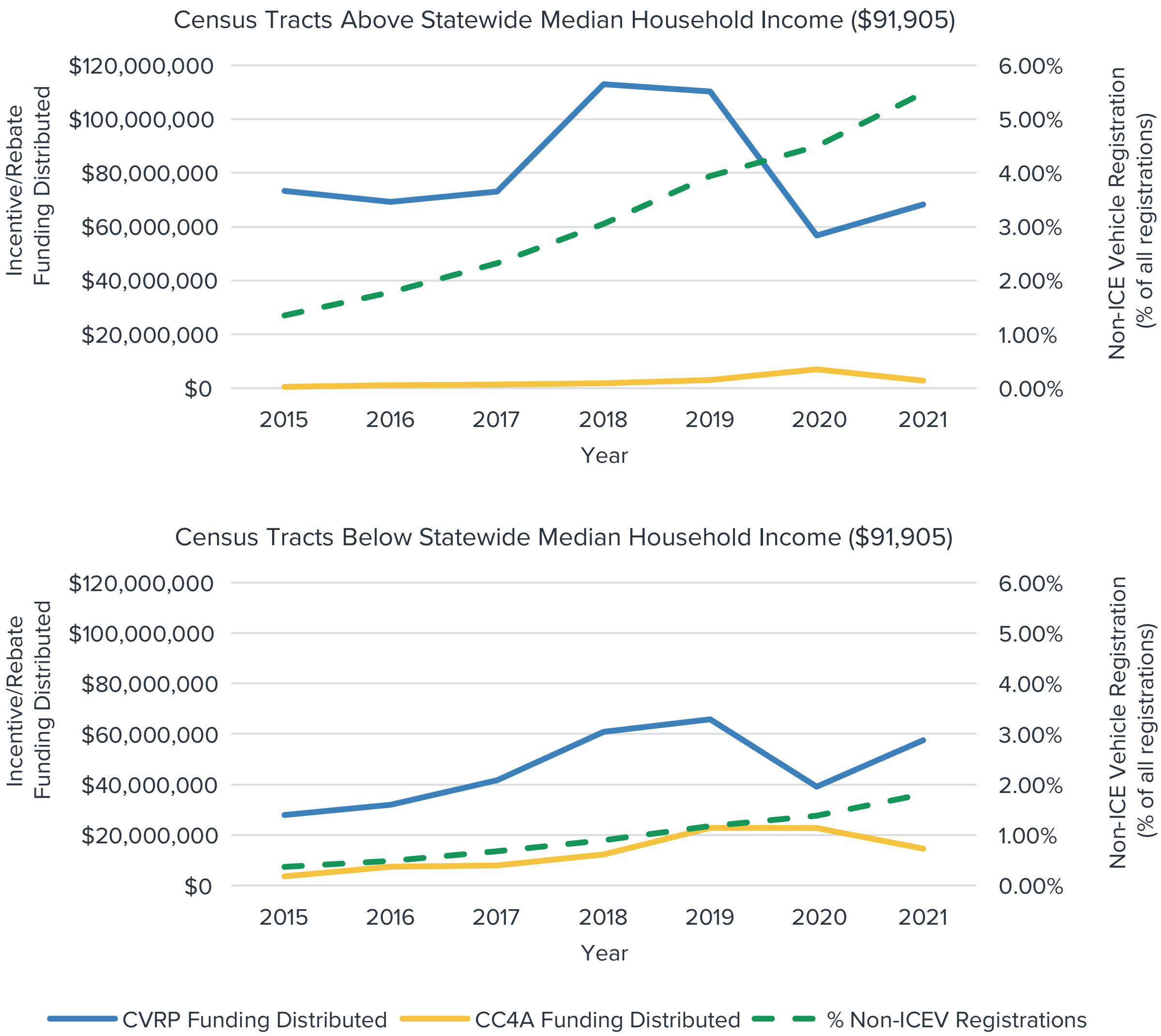
Total non-ICEV residential vehicle registrations in California by year and census tract median income, 2015-2021.



To visually assess the relationship between incentive funding and non-ICEV registration at different income levels throughout CA, we plotted total funding against non-ICEV vehicle registrations in Figure 5 (see Figure A-2 for a non-income stratified version of this figure). This figure demonstrates that in census tracts below the statewide median household income, CC4A and CVRP funding trends closely align with the increase in non-ICEV registration rates. However, in tracts above the statewide median income, non-ICEV registration has a significantly higher positive slope from 2015-2021. These charts also show the higher magnitude of funding distributed through CVRP in higher-income households versus lower-income households, as discussed previously. For CVRP, a significant dip in funding in 2020 can be seen, a result of the COVID-19 pandemic.

FIGURE 5

Incentive funding distributed by CVRP and CC4A to, and non-ICEV residential vehicle registration rates in, census tracts with median income above (top) and below (bottom) California median household income, 2015-2021.



Note: Median household income from 2018-2022 (U.S. Census Bureau, 2024)

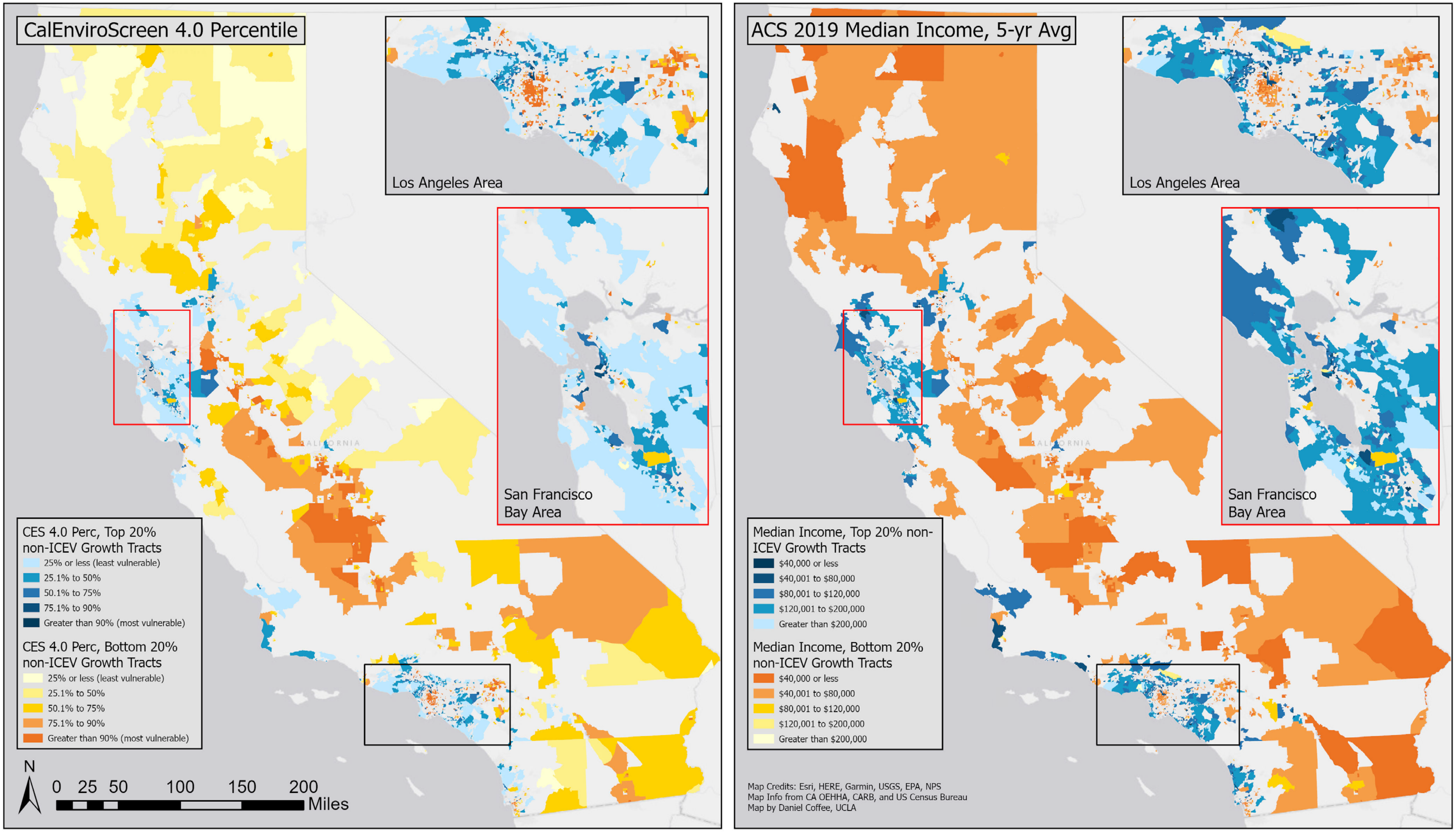
Finally, we find significant characteristic differences between the highest and lowest quintiles of tracts concerning the rate of non-ICEV adoption. From 2015 to 2021, California's highest quintile (top 20% of tracts) grew its non-ICEV residential fleet share at an average annual rate more than five times that of the lowest quintile (bottom 20% of tracts). These high-growth tracts tend to have low levels of environmental and socioeconomic burden (average CES percentile: 24%) and are quite affluent (average median income of nearly $131,000). In contrast, the lowest-growth tracts in the state have high levels of burden (average CES percentile: 73% – nearly above the 75th percentile threshold for automatic DAC-status qualification) and have much lower income levels, with an average median income of $48,500.

Figure 6 shows the geographic distribution of these two groups of tracts throughout the state, with the highest-growth tracts heavily concentrated along the coast and metropolitan areas. Most of these exhibit low CES percentiles and higher incomes, although a number of exceptions can be seen. Most of these tracts with higher CES scores are in the San Francisco Bay and Los Angeles areas. In the lowest-growth quintile, we see many of the state's more rural tracts – though many of these tracts are geographically large due to low population density – as well as smaller, more densely populated tracts in urban areas and the San Joaquin Valley. Many of these, especially those in the Los Angeles and San Joaquin Valley areas, experience high levels of environmental burden. Low-growth tracts are also characterized by low median income levels, with a handful of exceptions.

The geographic visualization also showcases a pattern wherein low-growth urban cores are surrounded by intermediate (between 20th and 80th growth percentiles) and then high-growth areas. This pattern is most clearly observed in the "bullseye" that appears in Los Angeles, where the low-growth (and low-income, high-burden) city core is surrounded by a ring of intermediate tracts, then high-growth (and generally high-income, low-burden) suburbs. The San Diego, Sacramento, and East Bay areas also exhibit this pattern, albeit less clearly.

FIGURE 6

Environmental burden and income disparities between California's highest and lowest non-ICEV growth quintiles, 2015-2021.*



*CES 4.0 percentile and median income brackets classified manually.

Along with descriptive data presented in the previous figures and tables, we also developed some bivariate correlations to examine the relationship between incentive distribution (both count of incentives and dollars distributed) and non-ICEV registration (Table 4).

Within all census tracts (left side of Table 4), these correlations are all positive and higher than 0.50 for all years for the count of incentives, and 0.40 for the incentive dollars distributed, demonstrating that as incentive distribution increased, non-ICEV registration increased as well. For DAC census tracts only, correlations remain positive, but slightly lower than for all tracts throughout the state, with increases from 2016 – 2021, except for 2020 (likely related to the pandemic, which impacted incentive funding).

Though these correlations indicate a strong positive relationship between incentive distribution and non-ICEV registration, it is important to note that these correlations do not account for other factors potentially associated with the two metrics, which is a limitation in deriving a conclusion about the statistical relationship between the factors.

TABLE 4

Census tract-level Pearson correlations between incentive distribution and non-ICEV registration in CA.

	All CA Census Tracts		DAC Census Tracts only	
Year	% Non-ICEV and Total Count of Incentives	% Non-ICEV and Total Incentive Dollars	% Non-ICEV and Total Count of Incentives	% Non-ICEV and Total Incentive Dollars
2015	0.70	0.69	0.40	0.36
2016	0.66	0.63	0.35	0.27
2017	0.60	0.57	0.40	0.35
2018	0.58	0.55	0.43	0.41
2019	0.56	0.51	0.46	0.41
2020	0.50	0.40	0.41	0.38
2021	0.62	0.57	0.50	0.45

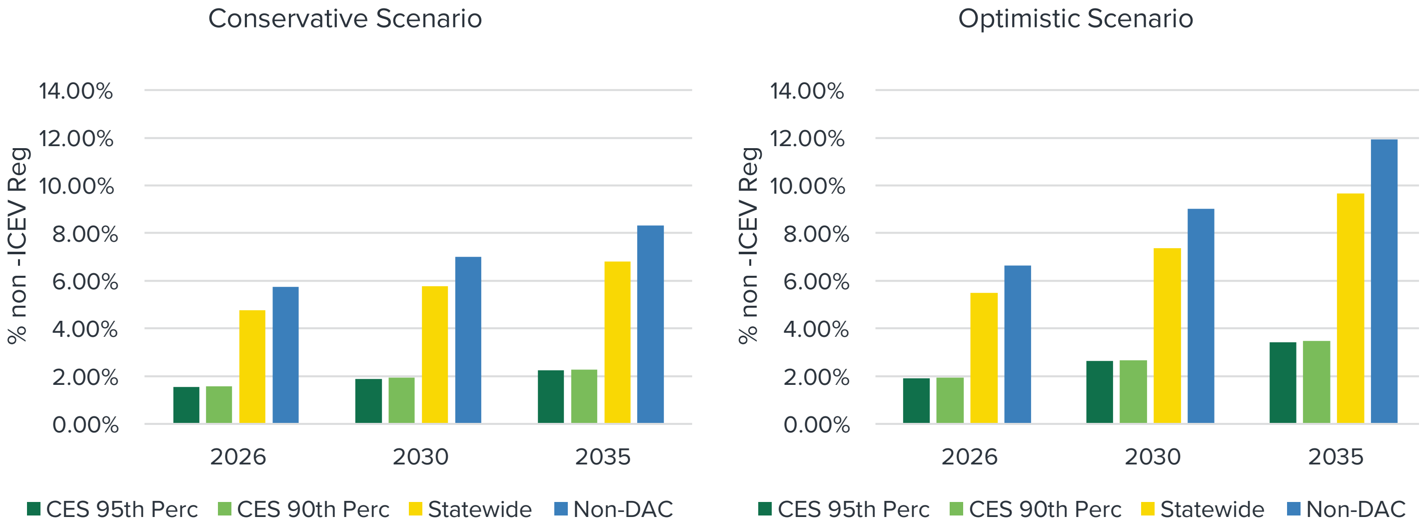
3.3. Looking Forward: Ways to Project California's Non-ICEV Growth

In order to build upon the above results and highlight potential challenges of California's push to decarbonize transportation equitably, we used the 2015-2021 EMFAC data to project non-ICEV registration rates forward to 2035 and worked backward from the goal of 50% statewide non-ICEV registration by 2050 (see *Data and Methods*, above). This projection exploration is meant as food for thought rather than a precise scenario analysis.

In both our conservative and optimistic projections (Figure 7), statewide registrations remain low even by 2035 (less than 7% and 10%, respectively). The most burdened tracts in the state lag far

FIGURE 7

Conservative and optimistic linear projections of non-ICEV registration growth rates in California, statewide, and by select subgroups (95th and 90th percentile CES tracts and non-DAC tracts), 2026, 2030, and 2035.



behind the statewide and non-DAC figures, barely exceeding 2% by 2035 in the conservative scenario and remaining below 4% in 2035 under the optimistic scenario. Although these highly burdened tracts make significant proportional gains under the optimistic scenario, they are outstripped by statewide growth, increasing the clean vehicle access gap between California's most vulnerable communities and the rest of the state.

Figure 8 shows three alternative scenarios that achieve a 50% statewide non-ICEV registration rate by 2050, showcasing the difference between what is necessary to achieve these goals and the scenarios based on current trends in Figure 7. The key delineating factor between the three scenarios in Figure 8 is the rate at which DACs (95^{th} and 90^{th} CES percentile tracts and other DACs below 90^{th} percentile) approach parity with the statewide registration rate. The status quo scenario assumes DACs continue to lag behind the statewide average, as in the optimistic scenario above, while the following two scenarios posit that DACs close the gap at double or triple that rate.

Under the status quo scenario, low non-ICEV penetration in DACs necessitates that non-DACs reach a registration rate of nearly 60% to achieve the statewide goal. Even this case would call for the most burdened DACs to achieve interim year registration rates more than double those in the optimistic scenario above. When DACs are able to close the registration gap faster, the disparity between current trends and the 50% by 2050 scenario is starker, with the most burdened tracts needing to approximately triple the non-ICEV registration rate of the optimistic scenario.

The equity benefits of closing the gap are readily evident; under a tripled rate of parity gain, DACs outside the 90^{th} CES percentile nearly draw even with the statewide and non-DAC registration rates. Greater gains in DACs would also reduce the challenges of achieving very high adoption rates in the rest of the state, lowering the necessary non-DAC rate to approximately 53%. Even in this case, California's most marginalized communities would remain far behind in clean vehicle access, with non-ICEV registration rates in the mid-20s (%).

FIGURE 8

Non-ICEV registration rate pathways to 50% statewide registration by 2050, based on varying rates at which DACs close the registration parity gap with the statewide average compared to the optimistic scenario.

4. CONCLUSION AND RECOMMENDATIONS

California's clean vehicle incentive programs have distributed more than 960,000 total incentives throughout the state since CVRP's inception in 2010. Since then, more than $310 million has been distributed to DACs, with proportionally more funding coming to DACs through the CC4A program – designed to target in-need populations – than through the statewide programs. We find that both incentive distribution and EV registration rates have increased steadily over time, and are highly correlated, though registration rates are significantly lower in DACs and lower-income communities. Should current trends persist, we project that non-ICEV adoption rates will fall significantly short of the state's goals. Even if registration rates are set on a course for 50% by 2050, California's most vulnerable communities will continue to lag far behind unless significant progress is made on improving adoption rate parity.

Unfortunately, the pursuit of fleet turnover in DACs faces an uphill battle given the lack of affordable EVs in the near term; though EVs cost less to operate and maintain over their lifetime, the upfront purchase prices are currently higher than equivalent ICEVs (NRDC, 2024). Federal U.S. Original Equipment Manufacturer (OEM) provisions are not helping bridge this disparity.

Here, we present several specific recommendations to support closing the equity gaps identified in our analysis. One such recommendation is to allocate more funding for programs to have a chance to reach 2035 targets, despite California's recent budget challenges. Since funding is limited, the state could further support EV ownership and ICEV fleet turnover for low-income households and DACs by designating program funding strictly to the most in-need populations, such as the bottom third of the income and disadvantage distribution, with less flexibility in eligibility requirements. Proposals such as Assembly Bill (AB) 2401, which targets DACs and high-emitting vehicles, support such objectives. AB 2401 requires the state to consider additional metrics regarding retired vehicles and also requires the development of a means-based strategy to identify the most in-need potential incentive recipients.

Additionally, we recommend maximizing the used vehicle inventory more strategically to be available for incentive programs, as well as improving charging infrastructure in low-income and disadvantaged communities. As far as CARB's Advanced Clean Cars (ACC) II regulations (amendments to which will be brought to the Board in 2025) are concerned, the equity provisions in ACC II could be strengthened by providing OEMs with increased market-based incentives to sell more affordable new EVs and redirect lease returns to the EV equity programs.

Vehicle financing is also a challenge for low-income and disadvantaged populations. Our ongoing work suggests that CVAP faced challenges due to being too restrictive on loan terms and not being able to finance enough risk. Revolving loan funds are one option that can be used to leverage dollars more effectively. The state's new joint CC4A and Financing Assistance program will take strides to improve needs-based participation opportunities through a tiered approach and will offer financing options for participants. This joint program will be formally called the Driving Clean Assistance Program (DCAP) and administered by the Community Housing Development Corporation.

We also encourage the state to continue pursuing the realization of a one-stop shop design for receiving access to household-level environmental benefits. Programs offered through such frameworks can lower energy bills, and the cost of electric vehicle supply equipment (EVSE) simultaneously. The state's Access Clean California program (pilot started in 2017) is designed to meet such needs. While they have built a substantial outreach partner network and established the "Benefits Finder" tool, it is not clear the extent to which the program has resulted in actual receipt of household benefits; the 2022 impact report states that 425 people began program applications, with only 136 income verifications throughout the state (GRID Alternatives, n.d.).

California's light-duty incentive programs can play a key role in achieving the state's impending light-duty fleet targets. Maximizing funding and ensuring equity in program implementation and incentive distribution will support the state in its pursuit of a just transition to clean energy for all California residents.

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6. APPENDIX

TABLE A-1.

Overview of programs

Program	Geography	Incentive Offering	Eligibility	Years Operating
Clean Vehicle Rebate Project (CVRP)	Statewide	Rebate for the purchase or lease of new, eligible zero-emission vehicles, including plug-in hybrid (PHEV), battery electric (BEV), and fuel cell vehicles	CA residents with a qualifying household income (income requirements established in 2019)	2010-2023
California Clean Fuel Reward (CCFR)	Statewide	Point-of-sale price reduction/rebate for the purchase or lease of eligible new PHEV or BEV	CA residents	2020-2023
Clean Cars 4 All (CC4A)	Regional (now 5 AQMDs)	Incentive for the retirement of an older vehicle and purchase or lease of an eligible hybrid, PHEV, BEV, or alternative mobility option	CA residents living in or near a DAC with a qualifying household income	2015-current
Clean Vehicle Assistance Program (CVAP)	Statewide	Buy-down grant and financing option for purchase or lease of a new or used PHEV, fuel cell, or BEV	CA residents living in a DAC with a qualifying household income	2018-2023
Drive Clean in the San Joaquin Rebate Program (DCSJ-RP)	San Joaquin Valley	Rebate for the retirement of an older vehicle and purchase or lease of an eligible PHEV, BEV, or other alternative fuel vehicle	CA residents living in the San Joaquin Valley	2015-2023
Southern CA Edison Pre-Owned Electric Vehicle Rebate Program (SCE-PreOR)	Southern CA Edison Territory	Rebate for the purchase or lease of an eligible pre-owned PHEV or BEV	SCE residential customers; income-qualified residents will receive additional funds (Rebate Plus)	2021-current

FIGURE A-1

Total distributed tract-level CVRP incentive funding, 2010-2023, by SB 535 DAC status.

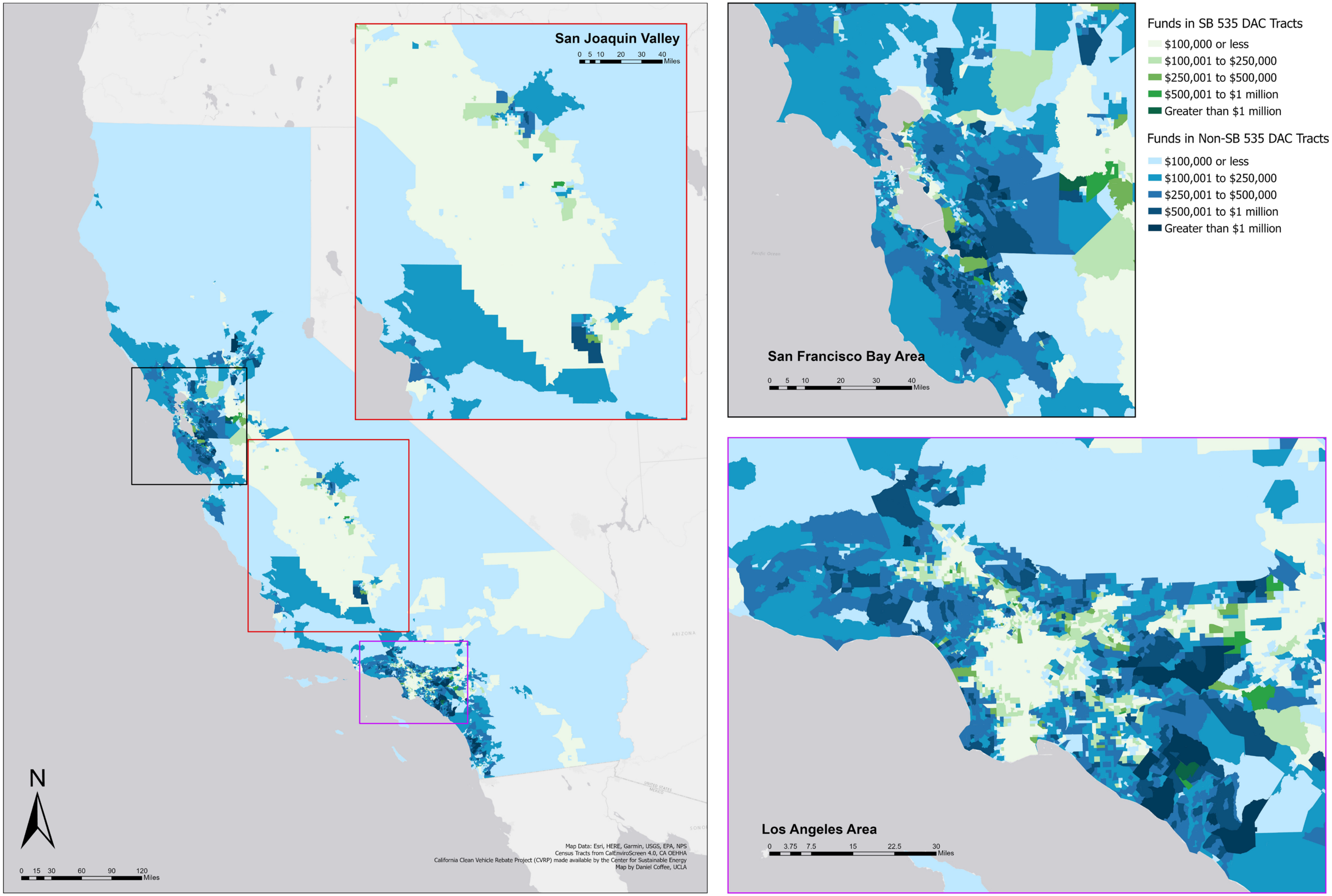
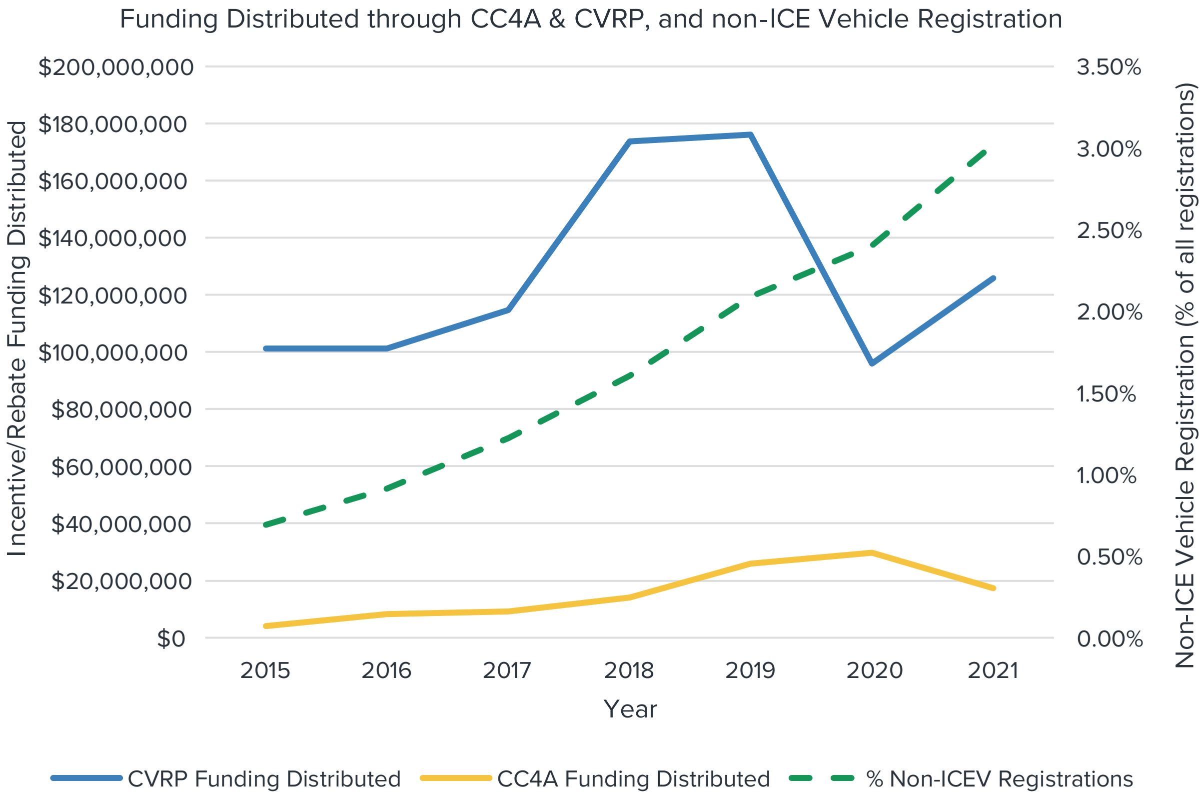


FIGURE A-2

Incentive funding distributed by CVRP and CC4A alongside non-ICEV residential vehicle registration rate, statewide, 2015-2021.



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