POISON IN THE HOUSING MARKET:

USING CALENVIROSCREEN TO MITIGATE THE NEGATIVE EFFECTS OF

POLLUTION ON PROPERTY VALUES

A Thesis

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by

Lindsay Kathleen Buckley

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Department of Public Policy and Administration

Abstract

of

POISON IN THE HOUSING MARKET:

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Since 2013, the state has used CalEnviroScreen to guide the allocation of more than $9 billion dollars of cap-and-trade revenue to mitigate environmental harm through the deployment of cleaner technologies, tree planting, transit expansion, and more, with a particular emphasis on places disproportionately impacted by pollution and at a socioeconomic disadvantage as compared to the rest of the California.

In this thesis, I sought to explore whether pollution as measured by CalEnviroScreen negatively impacts housing prices and the potential to mitigate such impacts through targeted government interventions to support economic development. I took a mixed-method approach conducting a regression analysis and then I interviewed four subject matter experts working in California environmental policy.

Using the Metrolist Multiple Listings Service and CalEnviroScreen as my sources, my regression analysis evaluated the effect of following indicators on the price of Sacramento County residential properties sold in 2016: pollution exposure, pollution effects, and property and neighborhood characteristics. My results showed the

CalEnviroScreen pollution indicators to have little negative effect with the exception of traffic density which I found to have a statistically significant negative effect on selling price translating to a $22,395 decrease in the selling price of single-family homes in areas with high traffic density. My interviews with experts revealed a positive perception of CalEnviroScreen, acknowledgment that the tool is in a continuous improvement process, and openness to expanding its use to support economic development in disadvantaged areas that is centered on community needs and decision-making.

Based on my findings, I recommend the state continue its investment in and use of CalEnviroScreen for targeted pollution mitigation in disadvantaged areas including exploring creative new efforts that build community capacity as a core aspect of economic development strategies. Additionally, policymakers should evaluate the value of public disclosure to increase awareness of environmental risk and public support for clean up or mitigation efforts.

_______________________, Committee Chair
Robert Wassmer, Ph.D.

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Date

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INTRODUCTION

Since 2013, the state has used CalEnviroScreen to guide the allocation of more than $9 billion dollars from the Greenhouse Gas Reduction Fund (GGRF) which is derived from revenue generated by the state’s cap-and-trade program. The California Legislature directed the California Protection Agency (CalEPA) to create CalEnviroScreen as a tool to identify priority areas for mitigation of environmental impacts. So-called “disadvantaged communities” or “DACs” are defined as places disproportionately impacted by pollution and at a socioeconomic disadvantage as compared to the rest of the California. Efforts to date have focused on mitigation of pollution exposure through the deployment of cleaner technologies, tree planting, transit expansion, and more (California Air Resources Board, 2019).

In this thesis, I use a mixed method approach to explore whether pollution as measured by CalEnviroScreen negatively impacts housing prices and the potential to mitigate such impacts through targeted government interventions to support economic development. First, I present a regression analysis of the price of Sacramento County residential properties sold in 2016, pollution exposure and effects, property and neighborhood characteristics in order to evaluate the effect CalEnviroScreen pollution indicators have on home values.

I then pair the regression study with qualitative interviews with subject matter experts to examine the prioritization of DACs for funding or programs that offset negative economic impacts of pollution exposure. Understanding whether and by what magnitude environmental risks as measured by CalEnviroScreen affect housing prices at both the individual and regional level may also help policymakers determine whether it is in the interest of homeowners to help fund clean-up costs through the levying of fees or taxes. Conversely, fees or taxes could be assessed on polluters to make up for the negative impact their industries have on local economies.

In the remainder of this introductory chapter, I provide an overview of the State of California's historical efforts to mitigate negative externalities associated with pollution. Then I detail how the state has approached addressing environmental justice issues through various law and policies eventually leading to the development of CalEnviroScreen. Finally, I describe how CalEnviroScreen has been used to date and new laws expanding its usage. The final section describes the remaining chapters in thesis.

State Efforts to Mitigate Environmental Externalities

California's efforts to address the negative impacts associated with environmental impacts were prompted by the fight against air pollution that began with the smog crisis of the mid-twentieth century. This is widely accepted to be an appropriate public policy response because the production of pollution is seen as a public good that benefits everyone but government intervention is necessary when the market fails to balance effects so that some are suffer disproportionately.

At its peak in the 1960s, alerts recommended Los Angeles residents stay indoors to avoid the detrimental health effects of smog (or ozone) more than 200 days a year (California Air Resources Board, 2018). Dubbed the "smog complex" by the L.A. County Medical Association, a survey found nearly 95 percent of respondents were experiencing symptoms including irritated eyes and throat, headaches, coughing, chest pains, and nausea (History of Smog, 2005).

Governor Reagan created the California Air Resources Board (CARB) in 1967 to specifically tackle the challenge of increasing air pollution resulting primarily from engine combustion and the burning of waste (California Air Resources Board, 2018). Regulations since that time have eliminated such alerts and reduced cancer-causing black carbon emissions from diesel more than 90 percent.

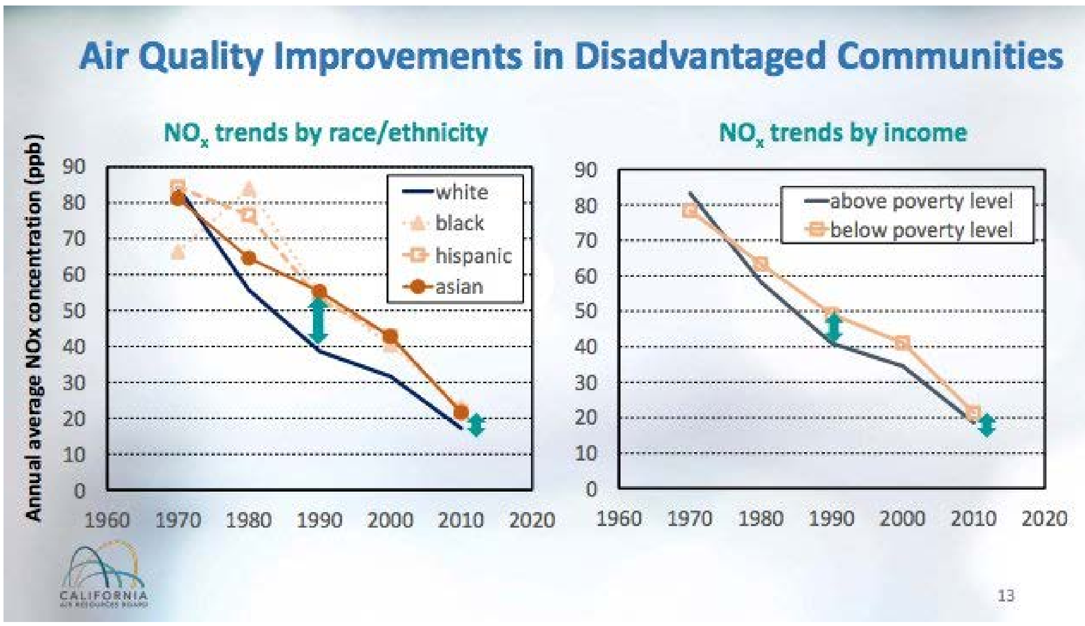
To tackle the emerging climate challenge, in 2006 Governor Arnold Schwarzenegger signed AB 32 directing CARB to develop a plan to reduce greenhouse gas (GHG) emissions 20 percent below 1990 levels by 2020 (California Air Resources Board, 2017). This action expanded CARB's purview beyond criteria and toxic pollutants to also include this primary climate-changing pollutant.

The bill also directed CARB to establish and consult with a committee representing environmental justice interests throughout the development of California's climate plan (Truong, 2014). When the plan was adopted in 2008, the committee remained in opposition to the state's preferred carbon pricing mechanism to reduce climate-changing gases, cap-and-trade, asserting the system would inadvertently result in an increase in localized emissions in some California locations, including those most harmful to human health, criteria and toxic pollutants.

The concerns of the environmental justice community are based in part on the state's historical efforts (Truong, 2014). Despite significant progress made to reduce air pollution, not all Californians have benefitted from these efforts equitably as shown in

Figure 1 below (California Air Resources Board, 2018). In particular, there is more to be done to close the gap in places most impacted by sources of pollution sources such as highways, railroads, ports, oil refineries and manufacturing facilities. For example, as shown in Figure 2 on the next page, the state's top greenhouse gas emitting facilities subject to the cap-and-trade regulation are primarily found in DACs (Office of Environmental Health Hazard Assessment, 2017).

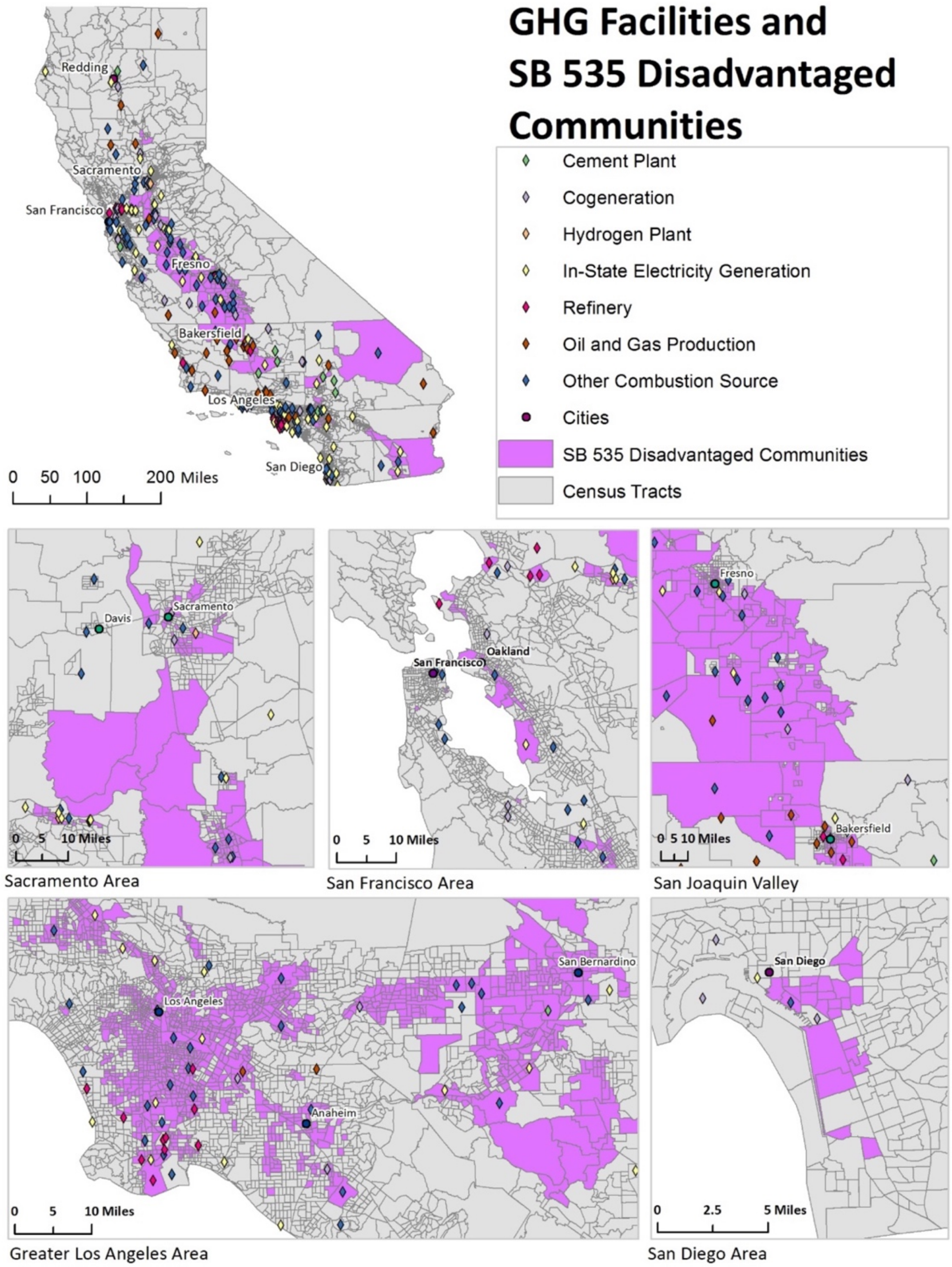
Figure 1: Air Quality Improvements in Disadvantaged Communities
Source: California Air Resources Board



Addressing Environmental Justice

Over the last several decades, the environmental justice movement emerged from these areas now known as disadvantaged communities, which are historically low-income communities of color, demanding historic wrongs be corrected and disproportionate impacts accounted for (Cole and Foster, 2001). Advocates gained significant political

Figure 2: GHG Facilities and SB 535 Disadvantaged Communities
Source: Office of Environmental Health Hazard Assessment



influence along the way as is evidenced by the myriad of state policies and programs adopted in the pursuit of environmental justice to date.

State efforts first began after Governor Gray Davis signed a series of bills from 1999-2001 charging CalEPA with the broad authority to “operationalize environmental justice goals” (California Environmental Protection Agency, 2001). Environmental justice is defined by California state law as meaning “fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies” (FindLaw, 2018). This first-in-the-nation effort made the agency responsible for integrating and prioritizing environmental justice considerations into programs, policies, and research to ensure equitable benefits of state programs and close the gap between disadvantaged and more affluent communities as illustrated in Figure 2 (California Air Resources Board, 2017).

The state presented its approach in CalEPA’s 2004 Environmental Justice Action Plan. The agency identified objectives, outlined implementation activities, and provided a timeline for key milestones in the plan (California Environmental Protection Agency, 2004). This document laid the groundwork for CalEnviroScreen in calling for the development of guidance to analyze cumulative impacts from sources of pollution facing communities throughout the state (California Environmental Protection Agency, 2004).

Analysis and stakeholder engagement informed the development of such a mechanism over the course of the following nine years. First CalEPA released a report detailing an approach and scientific methodology for analyzing pollution impacts and quantifying the effects using a tool in order to identify communities facing the highest burdens compared to the rest of the state (California Environmental Protection Agency, 2017). Then in July 2012 the agency unveiled a draft tool based on the report's recommendation, dubbed CalEnviroScreen 1.0, which was finalized in April 2013 after incorporating feedback from public review. Now in its third iteration, CalEnviroScreen 3.0 uses twelve pollution burden indicators and eight population characteristics to generate an overall score which is used to rank Census tracts from most disadvantaged to least disadvantaged (California Environmental Protection Agency, 2017).

The political environment significantly shaped the use and eventual impact of CalEnviroScreen. CARB developed and adopted the state's cap-and-trade program in parallel with the development of the tool. This was in large part meant to address the lingering concerns held by environmental justice advocates about the potential unintended consequences of the state's preferred carbon pricing mechanism (Truong, 2014).

Advocates asserted that this climate solution would ultimately increase local air pollution (Truong, 2014). Cap-and-trade is designed to reduce GHGs within an overall system of major polluters so it allows for trading between higher-emitting facilities and lower-emitting facilities around the state. At issue is how that mechanism affects levels of localized air pollution including traditional criteria pollutants such as ozone, NoX, and SoX which are most harmful to human health.

Critics maintain the program gives polluters a pass and in some cases levels of localized air pollution has increased near facilities under the program (Truong, 2014). Although there is not enough research to determine causation with cap-and-trade, there is enough correlation and community distrust for advocates to continue opposition to the system ultimately leading to a lawsuit against the state and a court decision requiring the state to monitor and evaluate impacts on an ongoing basis.

For these reasons, both advocates and policymakers viewed CalEnviroScreen as an essential solution to directly mitigate any unintended consequences of cap-and-trade and to provide reparations for historically disproportionate impacts of pollution. CARB projected the program would generate billions of dollars in revenue for the purposes achieving further greenhouse gas reductions and investing in clean energy technologies. Advocates organized behind a legislative effort to guarantee the funds would benefit communities most in need of relief from pollution. In September 2012, shortly after the first draft of CalEnviroScreen was released and two months before the state held its first cap-and-trade auction, Governor Jerry Brown signed SB 535 requiring 35 percent of the dollars generated by the system be spent in or benefit disadvantaged communities.

Current & Future Use of CalEnviroScreen

Since that time SB 535 emerged as the most prominent and impactful application of CalEnviroScreen. Per statutory direction, the top 20 percent of Census tracts with the highest CalEnviroScreen scores in the state are designated as disadvantaged by CalEPA and prioritized for programs using Cap-and-trade revenue. As of November 2018, more than $2 billion dollars, 57 percent of implemented investments, are benefitting low-income and disadvantaged communities, exceeding the requirement established by SB 535. Projects range from rebates and incentives for energy efficiency improvements, solar energy, and electric cars to community-level projects such as tree planting, affordable housing projects, and transit expansion. Administering agencies have implemented projects in 98 percent of the state's disadvantaged communities so far.

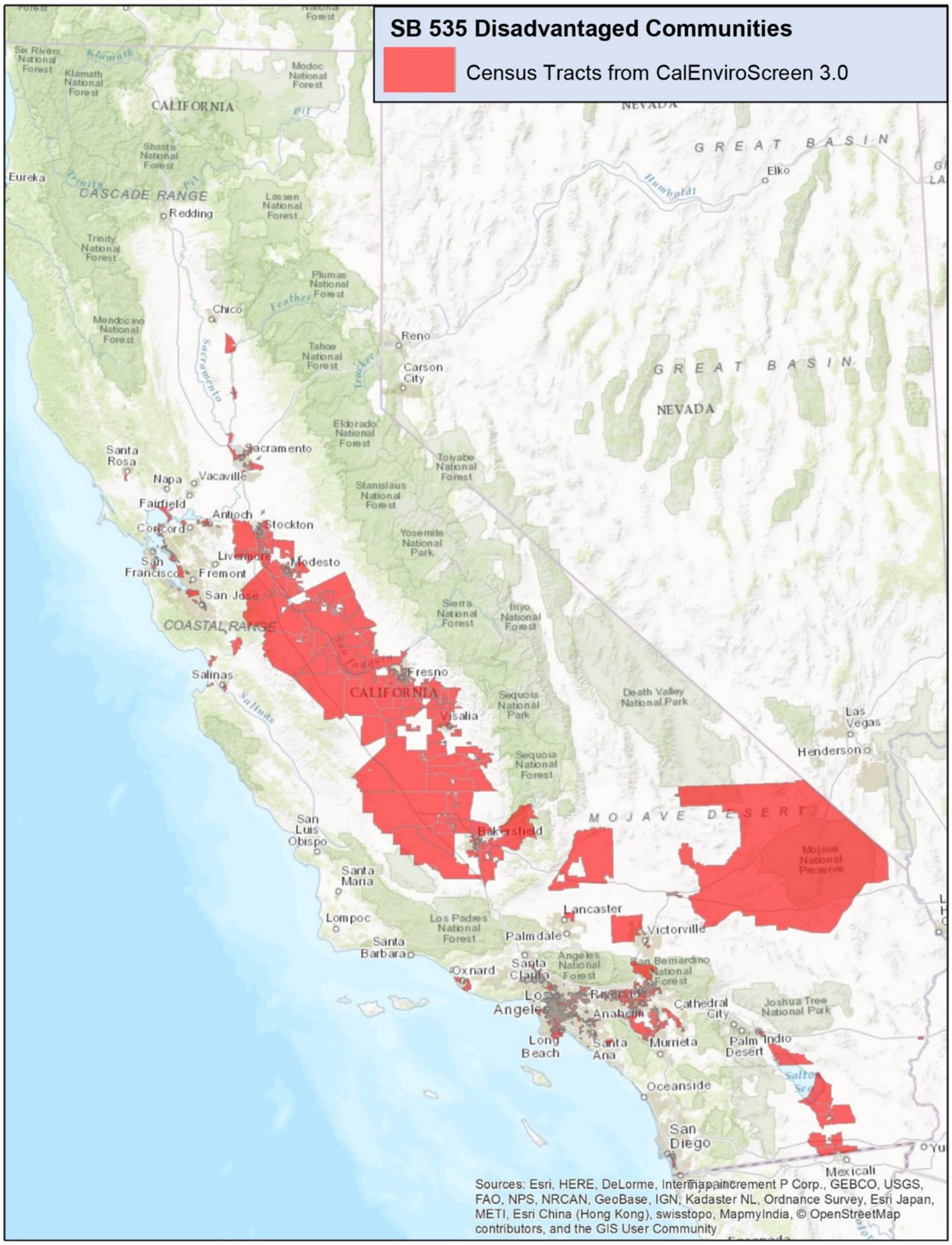
Over the last several years, the California legislature passed many different pieces of legislation expanding the use of the disadvantaged community designation due to the high visibility of CalEnviroScreen as a policy solution and the political capital of the environmental justice community. For example, more than 50 bills were introduced during the 2015-16 legislative session referencing the SB 535 designation creating a myriad of new programs directing cap-and-trade revenue and other funds to disadvantaged communities identified on the next page in Figure 3 in for electric vehicle charging, energy research, park bonds, affordable housing, and community air protection. One of the most significant bills, AB 1550, was signed in response to concerns of low-income Californians, dedicating at least five percent of cap-and-trade funds to provide focused relief to those facing disproportionate economic challenges.

Given the continued high level of interest in CalEnviroScreen as a policy solution and state's emphasis on balancing economic, environmental, and social considerations, it is appropriate and feasible to investigate its use to identify what pollution sources and effects negatively affect property values in order to consider prioritizing those areas for additional funding and focused mitigation efforts as my thesis explores.

The Remainder of the Thesis

In the next chapter, I offer a literature review in two parts. First analyzing studies exploring the development and use of CalEnviroScreen and then evaluating regression

Figure 3: SB 535 Disadvantaged Communities Census Tracts from CalEnviroScreen 3.0
Source: California Environmental Protection Agency



studies on the relationship between property values and environmental quality. I do this through the use of themes that help to inform both my mixed-method approach.

Then in Chapter 3, I provide an overview and offer results of the quantitative portion of my thesis, a hedonic regression study. First, I describe the motivation behind the chosen independent variables, how they relate to my designated dependent variable and outline the themes that make up my model including pollution exposure indicators, property characteristics, and population characteristics. Additionally, the chapter details the data used to evaluate the relationship between pollution burden and property values including types of data used, data sources, summary of descriptive statistics and compares each of the independent variables with the others to determine correlation coefficient.

In Chapter 4, I describe and summarize results of my qualitative method involving interviews with high-level state officials involved with the development and implementation of policies involving CalEnviroScreen. Finally, the conclusion in Chapter 5 considers the results of my analyses, explores the use of CalEnviroScreen to alleviate economic burdens and offer recommendations for policymakers when considering the use of CalEnviroScreen for new policies or programs using this information.

Chapter Two

LITERATURE REVIEW

Introduction

My literature review is presented in two sections. First, I review existing literature examining the development and use of CalEnviroScreen as the state's preferred indicator index for evaluating environmental impacts. Then I survey studies seeking to understand the relationship between property values and environmental externalities. The factors identified will inform my mixed method study involving regression analysis to evaluate the effect that environmental exposure and effects, as measured by CalEnviroScreen, has on property value.

Section A: Development and Use of Environmental Indicators Index

Two common themes emerged while reviewing existing qualitative literature regarding the development and effects of CalEnviroScreen that helped inform my study, specifically the importance of cumulative impacts and link between socioeconomic status and environmental exposure. The literature I reviewed primarily relied on case studies and document review. Two of the case studies involve robust research methods including field research, observation, interview, and first-person accounts documenting processes leading to the eventual development and implementation of CalEnviroScreen.

Importance of Cumulative Impacts

Researchers agree the most prudent approach to identifying the neediest communities is through an assessment of cumulative impacts (Faust, 2010; Huang and London, 2016; Liévanos, 2012; Sadd, Morello-Frosch, Pastor, Matsuoka, Prichard and

Carter, 2014; Truong, 2014). After a review of five case studies piloting the process in California, Faust (2010) described the approach as designed to cover effects resulting from being exposed to multiple sources of pollution known to impact health and well-being. Based on research by the US EPA, the state worked with communities to identify sources and pollutants of concern in order to develop a suite of environmental indicators used to determine cumulative impacts residents were experiencing.

The literature shows that the concept of assessing cumulative impacts dates back to the 1980s. Truong (2014) describes that the concept as captured by CalEnviroScreen is not new and was driven largely by apathy on the part of policymakers who resisted attributing environmental harm to one particular condition. Starting with a definition of cumulative impacts legitimizes public concern by accounting for and validating a community's lived experience. Evaluating cumulative impacts provides a baseline to drive action, facilitate decision-making, provide transparency and democratizes science (Faust, 2010; Huang and London, 2016; Liévanos, 2012; Sadd et al, 2014; Truong, 2014).

Huang and London (2016) asserted that cumulative impacts are a "wicked problem." Planning and designing solutions for such problems are so complicated they require creative approaches beyond what bureaucratic institutions are accustomed to including in-depth participatory and transparency elements. Many scholars note these are important co-benefits that can lead to high levels of trust and confidence in government agencies and elected officials, and provide for better outcomes for communities that have traditionally been left behind (Faust, 2010; Huang and London, 2016; Liévanos, 2012; Sadd et al, 2014; Truong, 2014).

The literature describes a myriad of challenges involved in evaluating cumulative impacts including gaps in information about sources, exposure, toxicity and understanding the overall effect of the impacts (Faust, 2010; Huang and London, 2016; Liévanos, 2012; Sadd et al, 2014; Truong, 2014). In addition to challenges, researchers acknowledge that cumulative impacts is a newer area of study and as such efforts to deploy methodologies using tools like CalEnviroScreen are experimental in nature. This requires ongoing evaluation of efforts which is another hurdle involved in implementing policy related to cumulative impacts but it can also provide opportunity to pilot new uses as policymakers are provided with an ongoing feedback loop.

Link Between Socioeconomic Status and Environmental Exposure

Scholars agree there is an inextricable link between socioeconomic status and exposure to environmental harm (Cushing, Morello-Frosch, Wander, and Pastor, 2015; Huang and London, 2016; Liévanos, 2012; Sadd et al, 2014; Sessions, Fortunato, Johnson and Panek, 2016; Truong, 2014). However the literature also acknowledges the connection is particularly challenging to identify quantitatively and therefore recommends mixed-method approaches to evaluating such impacts. I also found consensus in the value of pollution reduction and economic revitalization as co-equal goals.

Through a literature review Cushing et al (2015) found consensus that disadvantaged populations are disproportionately impacted by environmental exposures. This is especially the case in societies with high levels of inequality and also has the effect of elevating pollution levels for everyone. They conclude that these findings suggest policy interventions targeting disadvantaged groups would therefore provide benefits at a population level. Researchers also note that the area of study is relatively new and encourage additional inquiry.

In a 2016 paper, Sessions et al summarized major research underpinning philanthropic efforts to address the nexus between environmental health and equity, noting that low-income communities of color are two to three times as likely to be exposed to multiple sources of pollution as compared to more affluent populations. For these reasons, the authors how foundations increasingly see a link between economic opportunities and a healthier environment and are investing in those areas as a result.

Truong (2014) describes how environmental harms are regularly connected to poverty and asserts that the goal of the development and implementation of CalEnviroScreen is to address these historic conditions. The author argues that the state can mitigate “pollution and poverty” by funding sustainable economic revitalization in low-income areas. In two case studies examining and documenting the development of CalEnviroScreen, researchers describe the many goals envisioned by stakeholders and ultimately codified in statute including an overarching objective to direct money to state’s neediest communities in order to reduce pollution and improve overall economic conditions (Liévanos, 2012; Truong, 2014).

Section A: Conclusion

While this is a newer policy approach California is pioneering and there is limited literature, the research I found is detailed and comprehensive in its study of the use and goals of environmental indicators through CalEnviroScreen. There is general agreement among researchers close to the issue who assert that a cumulative impacts assessment approaching using a suite of indicators is the best practice for identifying communities in need of economic and environmental remediation. Additionally, the literature overwhelmingly concludes that socioeconomic status and environmental exposure is inextricably linked.

It is important to rely on a cumulative impact evaluation as the initial screen for determining where further focused-mitigation efforts are needed. Although in early development, the literature demonstrates that there is broad scientific consensus and public support continue to use and improve upon the approach. The literature also supports strategies to improve socioeconomic conditions through environmental mitigation.

These key takeaways will help inform the qualitative aspect of my study involving interviews with high-level officials working for the State of California involved in environmental justice, climate change, air pollution, and investments and implementation of programs funded with revenue from the state's cap-and-trade program. The interviews are intended to inform a set of recommendations for policymakers complemented by this literature review and my regression analysis.

Section B: The Effect of Pollution on Home Value

In the sampling of literature, I found property characteristics and neighborhood demographics to be the primary variables that affect housing prices. Despite differences in sampling and key explanatory variables, each study found environmental externalities to have a negative impact on housing prices and mitigation of pollution to have a positive impact. Each study I analyzed includes a regression analysis with one incorporating results from a stated preference survey. Appendix A summarizes these studies.

Basic Approach Used

Pollution's effect on property values can measured through a variety of approaches and data sets from a range of dates and differing locations. The sales price of a property is predominantly used as the dependent variable in most of the literature reviewed except for Guignet and Alberini (2015) whose research design incorporates stated-preference data survey using the measure of willingness to pay.

Location and timeframe are two main differences of the dependent variable across studies. In several studies, location is determined by the key explanatory variable researchers are intending to measure the effect of. Sullivan (2016) sought to analyze the effect of air pollution improvements associated with a Southern California regulatory scheme and as such pulled from a sample of in the area in which the regulation was in effect and at the time of the crisis that prompted clean air advances. Similarly, Davis (2011) used housing data from properties around power plants opened or closed in the 1990's to measure the impacts of the environmental risk they represent. Currie, Davis, Greenstone and Walker (2013) take the same approach in their study assessing the effect of toxic plant openings and closings in the 1990's. While results can be applied wider than the research area, it is important to use a sample of property values where and when the impacts of environmental harm is being felt. This decision ultimately depends upon the interest of the researcher and scope of available data.

Environmental harm is composed of a diverse set of pollutants, the individual effect of which are explored across the body of literature reviewed. As such, there are many different options for measuring it. Most of the literature uses proxies for pollution exposure as the key explanatory variable. Proximity to power plants, toxic plants, brownfields, and underground storage tanks are used by Davis (2011), Currie et al. (2013), Linn (2013), and Guignet (2012) respectively. Giudice, De Paola, Mangelli, and Forte (2017) use noise pollution levels. As the literature explains, these sources are proven to emit a variety of harmful pollutants and so where there is a relationship between those key explanatory variables and property values, it can be inferred that the same relationship exists for pollution levels.

Measurement is another difference in key explanatory variables. Proximity to pollution sources and direct exposure to measureable pollution levels are the two main ways researchers seek to analyze the relationship between property values and environmental health. There is also variation in distance and thresholds for exposure which influence the magnitude of the effect. Linn (2013) found a significant effect within a quarter of a mile of a brownfield compared to Currie et al (2013) who use a measure of a mile from toxic plants and Davis' (2011) two-mile threshold for effect of power plants. Studies looking at measureable exposure include noise pollution unit (Giudice et al., 2017) and levels of air pollution at both the regional and individual levels (Sullivan, 2017).

Controlling for Property Characteristics

Researchers point out that there are many other important factors affecting property value and recognize the importance of accounting for buyer preference bias by using property characteristic variables in their regression analyses (Linn, 2013; Guignet and Alberini, 2015; Giudice et all, 2017; Sullivan, 2017; Davis, 2011; Guignet, 2012). The number and range of characteristics included in the literature varies.

At a minimum, researchers account for number of bedrooms, number of bathrooms, square footage, and property age (Linn, 2013; Guignet and Alberini, 2015; Giudice et all, 2017; Sullivan, 2017; Davis, 2011; Guignet, 2012). Linn's 2013 study of the effects of brownfields considers a large number of property characteristic variables including bedrooms, bathrooms, square footage, and age in addition to more unique features like the presence of a fireplaces and structural material. Garages, heating and cooling systems, stairs and/or elevators, and plumbing are among other features accounted for. The lack of uniformity in property characteristics considered leads me to conclude that researchers incorporate what pieces of data are available to them.

One outlier study took a different approach. Currie et al (2013) decided not to account for property characteristics stating that because there is no evidence to show homeowners consider the proximity of a power plant as either a positive or negative amenity in assessing a home purchase, the other property amenity considerations are obsolete. The body of literature overwhelmingly disagrees therefore I find it to be the study's greatest research flaw.

Property Values and Environmental Externalities

While it is difficult to compare results because of the differences in sample of property values and key explanatory variable assessed, each of the studies analyzed demonstrate negative correlations between property value and levels of environmental risk, and a positive relationship between the mitigation of that risk and property values. The previous regression-based studies have found that the magnitude of effect increases as exposure levels get more specific and individualized and as pollution sources get closer to the properties assessed.

Sullivan (2017) used two different forms of air pollution data and ran two different regressions in the course of the study assessing property values and pollution exposure in Los Angeles. Results show that using an exposure number aggregated for the region shows no effect while using more specific neighborhood level data demonstrates property values increase by 1.8 percent as the air gets cleaner due to regulations on industry. This is because regional data is quantified using limited pollution monitors that are used to quantify an average applied to the entire region versus neighborhood specific data which varies and provides a point of comparison.

In assessing the magnitude of the effect, researchers primarily use percentage difference as the metric for change. For example, Giudice et al (2017) find a .30 percent decrease in real estate values for every decibel increase in noise pollution. Linn (2013) discovers that a brownfield cleanup increases property values by 1 percent. Davis' (2011) research reveals a 3-7 percent decrease in housing prices within two miles of a power plant. While Currie et al (2013) learn homes within one mile of an operating toxic plant to be 1.5 percent lower than similar properties. Guignet's 2012 study shows private well contamination to have a negative effect on real estate values by 9-12 percent.

Dollar figures are used rather than percentage change in Guignet and Alberini's (2015) study assessing willingness to pay for higher environmental quality. They find survey respondents reported a willingness to pay a significant premium for homes in areas with lower mortality risk. Additionally, they found that individuals who already affected by air pollution are willing to pay double that amount.

Another approach taken in the literature is to aggregate regional economic impacts quantified using dollars in addition to assessing the percentage change at the individual level. While Curry et al (2013) found a 1 percent decrease in property value for homes with one mile of a toxic plant is significant, a more impactful metric is the aggregate loss in housing value per plant which they found to be approximately $1.5 million. Similarly, Davis (2011) found a 3-7 percent decrease in property values within 2 miles of power plant to translates into an overall loss in housing value per plant is approximately $13.2 million.

Despite differences in variables and magnitude, the research indicates environmental harms of all types negatively impact property values. The literature also shows values increase when those risks are mitigated through pollution reduction, plant closings or site clean ups. While percentage change is important and valuable metric, the economic impact in a dollar figure serves to better convey the overall effect sources of pollution have on a community at large and can serve as a basis for levying clean-up fees that will provide benefits for all.

Section B: Conclusion

In reviewing the literature, I found nearly all of the studies use property value as the dependent variable with variations in sample, location, and timeframe. While researchers use a number of different pollutants and proxies for assessing environmental health, the results show that no matter the place, time or source analyzed, pollution exposure has a negative impact on property value to a varying degree even when accounting for buyer preference bias using property characteristic variables.

Identifying relevant variables to control for is essential to maintain the integrity of a regression analysis. The research overwhelmingly concluded both property characteristics and population characteristics as being most important to overall property value.

I find the lack of consideration of neighborhood characteristics to be the greatest weakness of the literature reviewed. Only one study recognized the effect that socioeconomic indicators have on property value and included education and poverty rates (Davis, 2011). These variables can serve as an important indicator for assessing the role information plays in the decision to live near source of pollution. Studies assume buyers have some information but the evidence lacks and should be researched further.

Chapter Three

REGRESSION METHOD AND FINDINGS

In this chapter, I will describe the quantitative portion of my thesis which uses a regression analysis to identify whether and by what magnitude CalEnviroScreen pollution indicators negatively affect home values. Selling price is used as the dependent variable for my analysis. The results will help me analyze whether it makes sense for decision-makers to use this information to develop policy interventions designed to improve those conditions to achieve economic benefits. I start this chapter by providing an overview of my quantitative analysis methods. Then I describe the results from this regression analysis.

Regression Framework

The dependent variable that I examine is the selling price of Sacramento County residential properties. My model is based on review of peer-reviewed regression studies analyzing the effect of pollution on home values, concluding the best control variables to use for such an analysis as falling into three categories including pollution exposure and effects, property characteristics, and neighborhood population characteristics.

Selling price = f (pollution exposure and effects, property characteristics, and neighborhood (Census) population characteristics),

where,

Pollution Exposure Indicators = f (Diesel Particulate Matter, Ozone, Particulate Matter 2.5, Drinking Water Contamination, Pesticides, Toxic Chemical Release, Traffic Density, Cleanup Sites, Groundwater Threats, Hazardous Waste, Impaired Water Bodies, Solid Waste),

Property Characteristics = f (Square footage, Bathrooms, Bedrooms, Fireplace Dummy, Homeowners Association Dummy, Pool Dummy, Years Old, Half

Bathrooms, One Story Dummy, Garage Spaces, Wood Exterior Dummy, Brick Exterior Dummy, Stucco Exterior Dummy, Remodel Dummy, Tile Roof Dummy, Shingle Roof Dummy, Metal Roof Dummy, Horse Property Dummy, Homeowners Association Dues),

Neighborhood (Census) Population Characteristics = f (Per Over 25 No HS, Linguistic Isolation, Poverty, Unemployment, Housing Burden).

Table 1 below offers a catalogue of the study's dependent variable and independent variables including description, source, and expected effect of each independent variable on the dependent variable of selling price. In this study, I expect pollution exposure indicators and population characteristics to have a negative effect selling price of a property while property characteristics will positively effect selling price. I then describe the rationales for the inclusion of each of these factors and the specific variables uses to represent them in this regression.

Table 1: Variable Description Sources & Expected Effects

Variable Name	Description	Expected Effect
DEPENDENT VARIABLE		
Selling Price	Property selling price	N/A
POLLUTION EXPOSURE INDICATORS		
Diesel Particulate Matter	Spatial distribution of gridded diesel PM emissions from on-road and non-road sources for a 2012 summer day in July (kg/day).	-
Ozone	Mean of summer months (May-October) of the daily maximum 8-hour ozone concentration (ppm), averaged over three years (2012 to 2014).	-
Particulate Matter 2.5	Annual mean concentration of PM2.5 (average of quarterly means, µg/m3), over three years (2012 to 2014).	-
Drinking Water Contamination	Drinking water contaminant index for selected contaminants	-
Pesticides	Total pounds of selected active pesticide ingredients (filtered for hazard and volatility) used in production-agriculture per square mile, averaged over three years (2012 to 2014)	-
Toxic Chemical Release	Toxicity-weighted concentrations of modeled chemical releases to air from facility emissions and off-site incineration (averaged over 2011 to 2013).	-

Variable Name	Description	Expected Effect
Traffic Density	Traffic density – Sum of traffic volumes adjusted by road segment length (vehicle-kilometers per hour) divided by total road length (kilometers) within 150 meters of the census tract boundary (2013)	-
Cleanup Sites	Sum of weighted sites undergoing cleanup actions within each census tract.	-
Groundwater Threats	Sum of weighted scores for leaking underground storage tank or cleanup sites within each census tract	-
Hazardous Waste	Sum of weighted permitted hazardous waste facilities and hazardous waste generators within each census tract	-
Impaired Water Bodies	Summed number of pollutants across all water bodies designated as impaired within the area	-
Solid Waste	Sum of weighted solid waste sites and facilities	-
PROPERTY CHARACTERISTICS		
Square footage	Property Square footage	+
Bedrooms	Number of bedrooms	+
Bathrooms	Number of bathrooms	+
Bathrooms Half	Number of half baths	+
Fireplace Dummy	Dummy variable = 1 if property has a fireplace	+
Fireplaces	Number of fireplaces	+
Homeowners Association Dues	Totally amount of HOA dues	?
Homeowners Association Dummy	Dummy variable = 1 if property is part of a homeowner's association	?
Pool Dummy	Equals one if property has a pool	+
Brick Exterior Dummy	Dummy variable = 1 if property has a brick-only exterior	-
Stucco Exterior Dummy	Dummy variable = 1 if property has a stucco-only exterior	+
Remodel Dummy	Dummy variable = 1 if property has been remodeled or updated	+
Tile Roof Dummy	Dummy variable = 1 if property has a tile roof	-
Comp Shingle Roof Dummy	Dummy variable = 1 if property has a composite shingle roof	+
Metal Roof Dummy	Dummy variable = 1 if property has a metal rood	-
Horse Property Dummy	Dummy variable = 1 if property has horse property	+
Years Old	Age of the property	-
NEIGHBORHOOD (CENSUS) POPULATION CHARACTERISTICS		
Per Over 25 No High School	Percent of the population over age 25 with less than a high school education (5-year estimate, 2011-2015).	-
Linguistic Isolation	Percent limited English-speaking households (2011-2015)	-
Poverty	Percent of the population living below two times the federal poverty level (5-year estimate, 2011-2015).	-
Unemployment	Percent of the population over the age of 16 that is unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty (5-year estimate, 2011-2015).	-

Variable Name	Description	Expected Effect
Housing Burden	Housing Burdened Low Income Households. Percent of households in a census tract that are both low income (making less than 80 percent of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50 percent of their income to housing costs). (5-year estimates, 2009-2013).	-

*Data for pollution exposure indicators and neighborhood population characteristics obtained from CalEnviroScreen 3.0
*Data for property and characteristics obtained from Metrolist Multiple Listings Service (MLS)

Data Sources

Pollution Exposure Indicators

The literature primarily consists of studies which are evaluating the effect of one environmental harm variable such as air pollution, proximity to power plants or groundwater threats or traffic. However, due to the richness of the CalEnviroScreen data set, I am able to consider all of these indicators together and more in my model. A wide breadth of pollution exposure indicators to get a better sense of what has the greatest effect on property values. Variables in this category are expected to have an overall negative effect on the dependent variable as pollution exposure has been found to be something individuals will pay a premium to avoid.

Property Characteristics

The literature identifies property characteristics as essential to the property value model. Buyer preferences are widely documented as having a major effect on property values. The 2016 Sacramento County Multiple Listing Service data set provides a wealth of information pertaining to property features, amenities, and location which are included in this model. Features such as square footage, number of bedroom and bathrooms typically have a positive effect on property values similar to amenities including pools and fireplaces. Location is accounted for in the model using zip codes which can have a positive or negative effect.

Neighborhood (Census) Population Characteristics

Several studies reviewed include population characteristics which are likely to affect the affluence of a neighborhood which influences property values due to availability of amenities, school quality, crime rate and more. The model includes five of these variable types from the CalEnviroScreen 3.0 data set. Each serve are indicators of the overall demographics and prosperity of the census tract where properties are located. These include percentage of the population in poverty, unemployed, with less than a high school degree, having limited English-language skills and those paying more than 50 percent of income on housing costs. Each of these variables are expected to have a negative effect on the dependent variable.

Dataset

Table 2 provides descriptive statistics for each variable used in this regression analysis. Data for both the dependent variable and property characteristics is provided by the Metrolist Multiple Listings Service (MLS), which tracked more than 6,000 Sacramento County residential single-family home sale transactions from September 1, 2016 through December 31, 2016. Pollution exposure indicators and neighborhood population characteristics come from CalEnviroScreen 3.0 which data by census tract.

Table 2: Descriptive Statistics (5,980 Observations)

Variable	Mean	Standard Deviation	Min	Max
DEPENDENT VARIABLE				
Selling Price	344729.4	149196.1	40000	2900000
POLLUTION EXPOSURE INDICATORS				
Diesel Particulate Matter	12.602	5.402	1.434	30.4
Ozone	0.049	0.002	0.044	0.055
Particulate Matter 2.5	9.186	0.432	7.859	9.536
Drinking Water Contamination	403.117	259.851	45.464	1004.339
Pesticides	7.529	46.8673	0	689.152
Toxic Chemical Release	130.532	444.805	18.329	16664.13
Traffic Density	813.494	443.522	93.6	2962.41
Cleanup Sites	4.875	7.976	0	75.75
Groundwater Threats	25.441	102.097	0	1610.25
Hazardous Waste	0.407	1.706	0	11.01
Impaired Water Bodies	3.195	3.867	0	20
Solid Waste	1.117	3.627	0	46.75
PROPERTY CHARACTERISTICS				
Square footage	1705.13	652.240	432	9213
Bedrooms	3.407	0.785	0	8
Bathrooms	2.036	0.624	0	6
Bathrooms Half	0.208	0.410	0	3
Fireplace Dummy	0.789	0.407	0	1
Fireplaces	0.865	0.539	0	5
Homeowners Association Dues	18.298	69.891	0	2400
Homeowners Association Dummy	0.136	0.343	0	1
Pool Dummy	0.180	0.384	0	1
Brick Exterior Dummy	0.005	0.072	0	1
Stucco Exerior Dummy	0.427	0.494	0	1
Remodel Dummy	0.495	0.500	0	1
Tile Roof Dummy	0.316	0.464	0	1
Comp Shingle Roof Dummy	0.612	0.487	0	1
Metal Roof Dummy	0.008	0.093	0	1
Horse Property Dummy	0.011	0.106	0	1
Years Old	56.097	185.018	1	2017
NEIGHBORHOOD (CENSUS) POPULATION CHARACTERISTICS				
Percent Over 25 No High School	12.592	9.357	0	48.5

Variable	Mean	Standard Deviation	Min	Max
Linguistic Isolation	6.525	5.236	0	32
Poverty	34.697	17.337	1	78.4
Unemployment	11.460	4.973	1.4	31
Housing Burden	16.815	7.469	1.8	45.9

Functional Forms

I began this study by analyzing the results of three different forms of regression analysis which are listed in Table 3 including lin-lin, quadratic, and lin-log. Each of these represent different options for a linear regression model procedure and help me determine which is the best fit for my dataset. I first started with a traditional linear regression where the coefficient represents what a one unit change in the independent variable means for selling price. I then used the quadratic model because several my independent variables have a minimum of zero. Finally, I ran the lin-log model wherein the dependent variable is squared and the resulting coefficient represents what a 1 percent change in the independent variable means for selling price.

Table 3: Functional Forms

	Lin-Lin		**Quadratic**		**Log-Lin**	
	Coefficient	**Robust Standard Error**	**Coefficient**	**Robust Standard Error**	**Coefficient**	**Robust Standard Error**
Constant	86858.36	41552.41	74379.88	55451.24	11.973	0.104
POLLUTION EXPOSURE INDICATORS						
Diesel Particulate Matter	1118.34***	406.418	-1606.004	1323.932	0.0008	0.000
Particulate Matter 2.5	-684.840	4461.443	1963.321	4536.857	-0.005	0.011
Drinking Water Contamination	-4.906	4.501	-6.159	4.470	-0.000	0.000
Pesticides	-2.869	22.329	-21.611	23.410	-0.000	0.000

	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Toxic Chemical Release	-2.22	2.867	-2.322	2.851	0.000	6.92
Traffic Density	-7.560***	2.222	-5.880***	2.212	-0.000**	5.79
Cleanup Sites	676.969**	274.071	1246.695***	419.847	0.001***	0.000
Groundwater Threats	-4.836	5.620	1.384	5.056	-0.000	0.000
Hazardous Waste	-888.623	880.028	57.325	869.036	0.0006	0.002
Impaired Water Bodies	2694.212***	374.301	-965.385	905.450	0.006***	0.000
Solid Waste	702.834**	350.678	1306.733***	336.0296	0.003***	0.000
PROPERTY CHARACTERISTICS						
Square footage	161.595***	7.856	44.42131***	9.641852	0.000***	8.81
Bedrooms	-21536.04***	2639.357	46954.43***	9881.308	-0.019***	0.004
Bathrooms	10816.14***	3351.532	50204.78***	13855.67	0.045***	0.006
Bathrooms Half	-1572.17	3442.393	-1228.626	3124.934	0.017***	0.005
Fireplace Dummy	-27955.93***	6796.67	19577.05	16956.57	0.029***	0.011
Fireplaces	27571***	6552.377	-29236.63	23590.12	0.017*	0.009
Homeowners Association Dues	159.076	105.669	29.17268	22.09263	-0.000	0.000
Homeowners Association Dummy	-29774.84**	13577.95	-17848.49***	3962.427	-0.027**	0.012
Pool Dummy	14940.92***	3266.816	18664.23***	2786.988	0.033***	0.005
Brick Exterior Dummy	63272.01**	31106.5	67967.18**	29118.9	0.071	0.045
Stucco Exterior Dummy	2301.607	1907.646	1066.537	1876.24	0.004	0.004
Remodel Dummy	25450***	1744.494	26189.05***	1744.688	0.081***	0.004
Tile Roof Dummy	-13553.56**	5561.911	-13947.31***	4876.67	0.006	0.010
Comp Shingle Roof Dummy	-18437.6***	5184.933	-18103.03***	4869.792	-0.033***	0.010
Metal Roof Dummy	-3837.504	11521.53	-471.1658	11101.4	0.024	0.027
Horse Property Dummy	86899.06***	19467.34	83681.58***	19530.79	0.167***	0.032
Years Old	14.5511**	5.722	-355.799***	132.452	0.000**	0.000
POPULATION CHARACTERISTICS						
Per Over 25 No High School	-1186.873***	179.476	-2941.279***	465.826	-0.006***	0.000

	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error	Coefficient	Robust Standard Error
Linguistic Isolation	-282.437	257.041	-1720.279***	566.856	-0.000	0.000
Unemployment	-1686.435***	268.8	-5889.152***	846.821	-0.004***	0.000
Housing Burden	-745.031***	174.296	644.999	610.670	-0.003***	0.000
Number of Observations	5857			5857		5857
R-Squared	0.809			0.829		0.835
Number of Significant Results	21			17		19

***Indicates statistical significance with 99 percent confidence
**Indicates statistical significance with 95percent confidence
*Indicates statistical significance with 90percent confidence

Multicollinearity

After running a basic linear regression analysis with no corrections, I then tested my data for multicollinearity using a VIF test. Table 4 includes the results of that test showing multicollinearity with ozone and poverty due to the VIF values exceeding 10. These results make sense since ozone is highly correlated with particulate matter 2.5 and poverty is highly correlated with each of the other population characteristics including percentage over 25 with no high school, linguistic isolation, unemployment, and housing burden. To adjust for multicollinearity, ozone and poverty will be removed from the model for the final regression.

Table 4: VIF Values for Independent Variables

Variable	VIF
Ozone	22.55
Poverty	12.14
Per Over 25 No High School	8.26
Particulate Matter 2.5	6.94

Diesel Particulate Matter	5.31
Tile Roof Dummy	5.18
Hazardous Waste	5
Square footage	4.7
Comp Shingle Roof Dummy	4.49
Cleanup Sites	4.29
Fireplaces	4.1
Housing Burden	3.74
Fireplace Dummy	3.74
Linguistic Isolation	3.67
Impaired Water Bodies	3.02
Drinking Water Contamination	2.99
Bathrooms	2.96
Unemployment	2.86
Homeowners Association Dummy	2.63
Solid Waste	2.49
Bedrooms	2.4
Traffic Density	1.93
Homeowners Association Dues	1.92
Toxic Chemical Release	1.86
Groundwater Threats	1.74
Horse Property Dummy	1.44
Bathrooms Half	1.33
Pesticides	1.33
Stucco Exerior Dummy	1.22
Pool Dummy	1.21
Metal Roof Dummy	1.17
Years Old	1.11
Remodel Dummy	1.1
Brick Exterior Dummy	1.07
Mean VIF	**3.88**

Heteroskedasticity

The study checked for heteroscedasticity in the regression running a Breusch-Pagan Test. The results were positive for heteroscedasticity with 99 percent confidence. Therefore, the model was adjusted in the final regression to correct for it using the (vce)robust command.

Regression Results

My regression analysis aimed to evaluate whether and my what magnitude pollution exposure as measured by CalEnviroScreen effect home values. Simple linear regression emerged as the best functional form due to the results having the highest number of statistically significant correlation and the ease of interpretation the form offers. Table 5 presents the results of my linear regression adjusting for multicollinearity by removing ozone and poverty and fixing heteroscedasticity using the (vce)robust command. Although not displayed in the results, this regression model also includes zip codes to account for location.

Key Findings

Despite what I expected in my research question and in contrast to what the literature shows, the study found pollution exposure to have little negative effect on selling prices. Of the eleven indicators included in the model, only one is shown to have a statistically significant negative effect on property value: traffic density. The three other pollution factors with statistically significant coefficients, were found to have a positive correlation with property values including diesel particulate matter pollution, and proximity to solid waste sites and impaired water bodies.

Table 5 displays the statistically significant results of my regression analysis and Table 6 displays isolates the pollution exposure variables with statistically significant correlations to property value.

Table 5: Most Statistically Significant Coefficients Where P > I.05I

Variable Name	Coefficient	Robust Standard Error	t	P>|t|	95 percent Conf.	Interval
Homeowners Association Dummy	-29774.84**	13577.95	-2.19	0.03	-56392.72	-3156.97
Fireplace Dummy	-27955.93***	6796.67	-4.11	0.00	-41279.95	-14631.90
Bedrooms	-21536.04***	2639.36	-8.16	0.00	-26710.17	-16361.91
Comp Shingle Roof Dummy	-18437.6***	5184.93	-3.56	0.00	-28602.01	-8273.18
Tile Roof Dummy	-13553.56**	5561.91	-2.44	0.02	-24456.99	-2650.13
Unemployment	-1686.435***	268.80	-6.27	0.00	-2213.38	-1159.49
Per Over 25 No High School	-1186.873***	179.48	-6.61	0.00	-1538.72	-835.03
Housing Burden	-745.031***	174.30	-4.27	0.00	-1086.72	-403.34
Linguistic Isolation	-282.44	257.04	-1.10	0.27	-786.34	221.46
Traffic Density	-7.560***	2.22	-3.40	0.00	-11.92	-3.20
Years Old	14.551**	5.72	2.54	0.01	3.33	25.77
Square footage	161.595***	7.86	20.57	0.00	146.19	177.00
Solid Waste	702.834**	350.68	2.00	0.05	15.37	1390.30
Diesel Particulate Matter	1118.34***	406.42	2.75	0.01	321.61	1915.07
Impaired Water Bodies	2694.212***	374.30	7.20	0.00	1960.44	3427.98
Bathrooms	10816.14***	3351.53	3.23	0.00	4245.88	17386.40
Pool Dummy	14940.92***	3266.82	4.57	0.00	8536.74	21345.11
Remodel Dummy	25450***	1744.49	14.59	0.00	22030.14	28869.87
Fireplaces	27571***	6552.38	4.21	0.00	14725.88	40416.12
Brick Exterior Dummy	63272.01**	31106.50	2.03	0.04	2291.61	124252.40
Horse Property Dummy	86899.06***	19467.34	4.46	0.00	48735.77	125062.40

***Indicates statistical significance with 99 percent confidence
**Indicates statistical significance with 95percent confidence
*Indicates statistical significance with 90percent confidence

Table 6: Most Statistically Significant Pollution Exposure Coefficients Where P > 0.05 (or 95% confidents that effects is statistically significant from zero)

Variable Name	Coefficient	Robust Standard Error	t	P>|t|	95 percent Conf.	Interval
Traffic Density	-7.560***	2.222	-3.4	0.001	-11.917	-3.203
Solid Waste	702.834**	350.678	2	0.045	15.373	1390.295
Diesel Particulate Matter	1118.34***	406.418	2.75	0.006	321.607	1915.073
Impaired Water Bodies	2694.212***	374.301	7.2	0	1960.44	3427.983

***Indicates statistical significance with 99 percent confidence
**Indicates statistical significance with 95percent confidence
*Indicates statistical significance with 90percent confidence

A significant outcome of the study that has implications for policymakers is that traffic density has a negative effect on property values. The effect translates to a $7 decrease in the selling price of a home in Sacramento County in 2016 for every one-unit increase in traffic density, an indicator measured on an 800-unit scale. This amounts to a $707 decrease in selling price in areas of low traffic density and a $22,395 decrease in the selling price in areas of high traffic density.

Aside from the negative economic impact, traffic density is also correlated with higher levels of air pollution which has negative public health and environmental impacts (California Environmental Protection Agency, 2017). Therefore, it may be in the interest of property owners to pay a fee for local transportation investments that decrease traffic density or vegetation improvements which serve as barriers for air pollution related particulate matter. Finally, being that this data shows traffic and air pollution as having a negative economic impact, this data could be used to prioritize transportation-related state investments that will help improve both public health outcomes and prosperity of property owners.

Aside from the negative correlation with traffic density, the results pertaining to the other pollution exposure indicators were not what I expected to find and I believe show that homebuyers are making purchasing decisions with incomplete information about environmental hazards. Policymakers should consider whether it is in the interest of the public good for these environmental indicators to be disclosed to potential homebuyers because there may be a hidden cost due to the effects of pollution exposure because people are currently unaware.

Chapter Four

QUALITATIVE METHOD AND FINDINGS

My thesis uses a mixed-method approach to complement the quantitative regression analysis with a quantitative study consisting of interviews with subject matter experts closely involved with development and use of CalEnviroScreen. This process was designed to help me assess feasibility by grounding the conclusions and assumptions of my quantitative analysis in the current political context before forming recommendations. While my regression analysis provided data-based insights into the relationships between pollution and property values, this portion of my thesis provided the opportunity to bring those findings to real world practitioners with a finger on the pulse of what is technically and politically appealing and practical. In this chapter, I offer an overview of my qualitative research approach and describe the major themes of my interviews

Research Design

I conducted and recorded interviews with individuals working on and influential in advancing environmental justice within high-levels of California state government. The sessions were preferably held in-person with the option for exchange via video conference or telephone. Participants were selected based on institutional history, knowledge and expertise in California environmental justice and policy in addition to and understanding of political environment.

I used open-ended questions designed to widely explore the feasibility, advantages, and disadvantages of expanding the use of CalEnviroScreen to implement strategies to improve local economies through the mitigation of pollution that negatively affects property values. First, I inquire about their history with CalEnviroScreen, confidence in its design and value it has provided to date. I also explore their ideas for possible changes, additions or expansions to both the tool itself and its uses. Finally, I offer my quantitative results directly and ask for their response and ideas about the appropriateness of targeting economic improvements through environmental mitigation.

Sample

I interviewed a total of four participants both in-person and on the phone recording each discussion using a mobile application. Although a limited sample, the interviewees represent the major stakeholder groups interested in the issues around pollution mitigation and environmental justice in California. Due to my work, the participants were known to me as colleagues or professional acquaintances. While a random or confidential sample would have ideal for objectivity, the complexity of the issues require specialized knowledge and expertise in order to inform feasible policy recommendations.

To ensure I considered a balance of perspectives, people from the following backgrounds were interviewed:

- One environmental justice representative from a state agency,
- One academic researcher,
- One Assembly staff member,
- One lobbyist who has represented entities covered by cap-and-trade.

However due to dynamic educational backgrounds and career shifts over time, I found my sample offered perspectives that were representative of more than just their current role providing for broader and richer discussions.

Data Collection

I identified interview participants using literature and existing networks. Then I provided invitations via email and subsequently followed up with phone calls. I was able to leverage existing personal and professional connections to secure participation bypassing the need to provide incentives. I obtained approval for the research design and questions through Sacramento State's Human Subjects Research review process.

Four 30-minute recorded interviews were scheduled and conducted at the convenience of the interviewee. The anonymity of interview subjects is preserved in this study in order to gain greater trust and insights that would otherwise be limited in official capacities.

Interview Results

As described above, I interviewed four individuals to inform my qualitative analysis. During the interviews, I asked a series of questions designed to elicit an unbiased discussion through open-ended query in order to better understand political feasibility, attitudes, and interest in addressing environmental justice concerns through economic development using CalEnviroScreen. In this section, I organize and present the responses into four broad themes including:

1. Attitudes about CalEnviroScreen
2. Perspectives on the link between pollution and housing prices

3. How economic development should be approached in disadvantaged communities
4. Suggestions for future improvements and uses of CalEnviroScreen

I provide a summary of the responses in Appendix C.

Attitudes About CalEnviroScreen

A majority of interviewees agreed that CalEnviroScreen has had a positive impact by providing a tangible understanding of environmental impacts and overall picture or “scorecard” to evaluate or rank communities for the purposes of prioritization for funding and other government interventions. All participants acknowledged the limitations of the tool and emphasized how its design provides an “at-a-glace” view and therefore its expanded applications should be carefully scrutinized. Many noted the “race-to-the-bottom” phenomenon, a perverse incentive driving competition among communities to be designated as disadvantaged in order to qualify for additional state funding.

Funding prioritization emerged as the top best use among all interviewees. I found consensus that using the tool as state policy to identify and direct funds has been successful in providing benefits to communities most burdened by the cumulative effects of environmental harm and negative socioeconomic conditions. I was surprised to hear agreement from the industry lobbyist that CalEnviroScreen is a good way to look at how grant dollars are being spent. However, they also suggested more should be done to ensure the expenditures are delivering on the promises made to deliver environmental and other benefits.

Despite my initial expectations, each of the interviewees expressed some level of caution in solely using the individual data layers to direct funding or inform policy decisions. Participants expressed concerns with data quality and the potential unintended consequences of using indicators without other important context like risk or impact information. They explained that not all indicators can be compared apples-to-apples. For example, if someone living near a polluted water body has far less of a health risk than someone living in an area with high pesticide exposure. Despite these warning, interviewees did seem to support exploring such uses especially since the state has made it available to the public.

Perspectives on the Link Between Pollution and Housing Prices

I prompted interviewees with a summary of my regression results and a related line of questioning to hear their reaction and interpretations of the findings. Interviewees were surprised by the results and keenly narrowed in on the limited data set as a key factor asserting that a broader statewide evaluation or look at other regions would likely garner different results.

The state agency attorney noted that Sacramento has unique environmental concerns observed at a regional level which may be part of what caused a lack in housing price differentiation between more polluted and less polluted areas. This is compared to regions like Los Angeles where pollution concerns are more localized due to industrial sources of pollution, such as oil and gas production facilities. For this reason, a higher variation in CalEnviroScreen indicator scores are seen in areas with these environmental exposure concerns. They described that these concerns are also more visible and known to the public, therefore having the potential to affect behavior more directly versus unknown or invisible pollution experienced in Sacramento County like ozone, impaired water bodies, solid waste facilities and clean-up sites. Several participants pointed out the same is true for traffic because it is among the most visceral CalEnviroScreen indicator and impacts daily life through audible disruptions, observational hazards, general inconvenience, and more.

The panel also agreed that economic and social considerations such as wasted time or gas money is likely the primary motivation driving lower housing costs in areas with high traffic density as opposed to environmental or public health concerns. They also noted a lack of environmental literacy among Californians and suggested there could be a role for the state in disclosing environmental harm and risk through information dissemination. However interviewees cautioned this approach could lead to unintended consequences though raising prices in more desirable, less polluted areas and leave disadvantaged communities behind. They emphasized that the original purpose of the tool was to identify areas most in need as opposed to areas to avoid but were intrigued by the possibility that a focus on disclosing CES information to residents could create pressure from the public to prioritize clean up and additional environmental mitigation where its needed most.

How Economic Development Should Be Approached in Disadvantaged Communities

A majority of participants shared concern about targeting DACs for economic development and offered alternative strategies for revitalization. Participants expressed hesitation in funding traditional economic development strategies such as special tax districts or opportunity zones which have historically led to displacement and gentrification in these areas.

Several mentioned the Transformative Climate Communities (TCC) program as a great example of nontraditional economic development strategy centered around meaningful community engagement designed to identify and address specific needs, build capacity, and provide opportunities for residents. The importance of additional context including anecdotal qualitative data as opposed to traditional economic development metrics was also noted.

Future Improvements and Applications Of CalEnviroScreen

Participants agreed on the overall value of CalEnviroScreen as a policy tool and provided suggestions for future improvements throughout the interviews. Ideas for improvement primarily focused on expanding what indicators are included and providing more granularity at a neighborhood level as well as historical trend information. Several participants mentioned incorporating risks from extreme heat, wildfires and more as climate change intensifies. The state agency official emphasized that more detailed data would increase the usefulness of CalEnviroScreen as a planning tool and help policymakers understand what areas are not seeing improvement over time.

I found a major difference in opinion between the academic and the industry lobbyist when it came to specific suggestions about including race or additional socioeconomic information. The academic finds these additions to be essential based on empirical research linking socioeconomic status to negative health outcomes including those linked to environmental health hazards while the industry lobbyist asserted such data is outside of the original scope of CalEnviroScreen. Ironically, they also recommended adding information to demonstrate societal impacts of pollution sources such as jobs and tax revenue benefits.

Regarding future uses of CalEnviroScreen, as described previously interviewees expressed interest in using individual layers to analyze issues as demonstrated in my quantitative analysis but they also voiced caution. The most common hesitation centered around data including integrity and appropriateness. Several participants rightfully noted that public agencies already use data to inform decisions and suggested that an expanded use of CalEnviroScreen layers should be additive rather than exclusive.

Qualitative Analysis Conclusion

My four interviews were enriching, engaging conversations that provided me with important perspectives and concrete ideas for policymakers directly from experts in the field. One of the key outcomes is how the responses validated my initial hypothesis with regards to pollution having a negative source on economic conditions which is supported by the literature. The discussions also affirmed that CalEnviroScreen is largely seen as a success in achieving what it was designed to do in directing cap-and-trade funds to areas with the most cumulative environmental impacts but that more can be done to deploy the tool and disclose CalEnviroScreen data to residents in a way that impacts community outcomes. Interviewees expressed support for future updates, improvements, and innovative uses. I found the interviews to be an essential complement to my limited quantitative analysis. It helped me understand public perception and capture the creativity of experts, demonstrating the importance of a mixed-method approach when analyzing complex public policy issues. In the following chapter, I will summarize my results as a whole, offer policy recommendations and present overall concluding thoughts.

Chapter Five

CONCLUSION

In this thesis, I sought to explore the questions: does pollution negatively impact housing prices? And if so, is there a role for targeted government interventions to support economic development in those areas? I took a mixed-method approach conducing a regression analysis evaluate the effect pollution as measured by CalEnviroScreen pollution indicators has on home values in Sacramento County and then I interviewed four subject matter experts working in environmental policy in California.

Findings on Effects to Home Values

As the economic indicator variable, my regression analysis used the selling price for 5,980 single-family detached homes sold in Sacramento County in 2016 using the Metrolist MLS as my source. I described environmental harm using thirteen CalEnviroScreen pollution indicators as my variables while controlling for property and neighborhood characteristics from both Metrolist MLS and CalEnviroScreen respectively. My findings were surprisingly inconsistent with my hypothesis and in contrast to the literature showing that pollution exposure reduces homes prices when included in a hedonic regression analysis of home prices.

Important quantitative results included:

- Pollution exposure as measured by CalEnviroScreen has little negative effect on selling price of single-family homes in Sacramento County;
- Traffic density is the only CalEnviroScreen environmental exposure or effect I found to have a statistically significant negative effect on selling price which

translates to a $7 decrease in the selling price of a home in Sacramento County in 2016 for every unit increase in traffic density, an indicator measured on an 800-unit scale. This amounts to a $707 decrease in selling price in areas of low traffic density and a $22,395 decrease in the selling price in areas of high traffic density; and

- Several indicators were found to have a statistically significant positive correlation with property values including diesel particulate matter pollution, and proximity to solid waste sites and impaired water bodies.

Based on these findings, I must conclude that at least in Sacramento County, pollution exposure as measured by CalEnviroScreen does not have a negative effect on housing prices. I explored the reasons my study may have conflicted with existing research on the subject in a series of interviews with experts. Several different themes emerged to account for these divergent results including the limited dataset, unique pollution concerns in Sacramento County, lack of awareness of environmental risk, and competing priorities including proximity to major pollution sources like urban centers or freeways for the trade-off of convenience.

Findings on CalEnviroScreen Attitudes & Funding Feasibility

The four individuals I interviewed have been involved with CalEnviroScreen since it was first created. In addition to thoughts on my quantitative findings, I asked questions designed to understand various perspectives on the tool and how proposals to expand its use might be received in the current political context. Each of these experts have changed roles over the years providing me with a myriad of cross-sectoral and multi-disciplinary viewpoints in addition to a real-world grounding in the political environment. Key themes from the interviews include:

- CalEnviroScreen is generally viewed positively due to how it has been used to successfully prioritize funding and provided communities with direct benefits and a tangible way to describe cumulative impacts of pollution to residents and policymakers alike;
- Now in its 4th version, it is widely accepted that CalEnviroScreen is in a continuous improvement process, being that it is the first of its kind, and therefore it should be used in combination with other tools and information including community-science, anecdotes, or other known datasets;
- Centering community needs and decision-making around economic development in disadvantaged areas is essential to ensuring equitable outcomes that avoid displacement and provide direct benefits to residents; and
- The state should maintain efforts and dedicate additional resources to expanding and improving CalEnviroScreen with additional detail and information to make the tool more usable and to help identify areas that are not experiencing improvements.

Recommendations for Policymakers

My findings support ongoing implementation, improvement and expansion of CalEnviroScreen to address environmental justice in California as mandated by state law but also serves as a cautionary example of its limitations and importance of using additional information to ground truth conclusions based on data alone. Based on this, I offer the following set of recommendations:

- Prioritize updating and improving to the tool to reflect the Newsom administration's priorities. This would include a robust, transparent public process to facilitate discussion around themes identified in my research including data sources, integrity, and granularity, and innovative uses such as application of individual indicators or integration into other decision-making processes.
- Consider community capacity as an economic development strategy and prioritize funding high impact programs like Transformative Climate Communities.
- Create a clearinghouse of other tools used in concert with CalEnviroScreen and case studies about innovative applications at the state, regional and local level to promote use and awareness.
- Evaluate the value public awareness and disclosure requirements. The state has invested a lot of resources into CalEnviroScreen and people deserve to know what their risk is despite unintended consequences that might results such as increased public pressure for clean up or scrutiny of elected officials for their role in neglecting environmental health concerns of impacted communities. I believe it is in the interest and obligation of public officials to embrace the tool and get in front of any potential backlash.
- Better define CalEnviroScreen or it is at risk of being used to advance special interests that may not be aligned with what was intended to do.

Limitations of Research

One challenge to this study is the limited span of available property value data. The 2006 data used is at a time when the real estate market in Sacramento County is at an all-time high and development is booming in new areas. Therefore, it is likely that the data is skewed by trends in the market that could be better analyzed incorporating data from more years over a greater span of time. Additionally, many urbanized areas of Sacramento are experiencing an economic renaissance due to gentrification which is driving up home prices in low-income and disadvantaged areas historically in closer proximity to solid waste and clean-up sites.

I also believe the positive correlation between diesel particulate matter levels and property value is more likely related to proximity to roads due to buyers preferring transportation access points rather than seeing air pollution as a positive attribute. Future research should account for these variables.

Lastly, the analysis is limited by a lack of access to maps of the various pollution exposure factors. The state plans to make maps of the twenty indicators in CalEnviroScreen 3.0 available eventually. These maps would help me identify the particular physical and geographic features in areas affecting property values where there are also strong positive relationships with pollution exposure factors including diesel particulate matter, cleanup sites, impaired water bodies and solid waste to get a clearer sense of what is really affecting selling price in these areas.

Opportunities for Further Research and Concluding Comment

CalEnviroScreen provides a rich and diverse dataset of pollution and population indicators by census tract. This public asset represents nearly limitless research potential now and in the future as the tool is further refined.

Due to its groundbreaking nature, I believe it would be valuable to have more research efforts dedicated to the tool itself including evaluating the data and its overall effectiveness. Surveying end-users such as advocates or public agency staff about how the tool is being used or influencing policy could help inform future updates. Deeper case studies could offer other practitioners ideas for leveraging CalEnviroScreen in their own work.

Finally, I would be interested to expand my regression analysis beyond Sacramento County to evaluate other key regions, especially those whose impacts are seen, heard, or felt such as areas with oil and gas facilities. Incorporating a broader geographic area would provide a better understanding of the overall statewide effect versus how the impacts are experienced at a more localized-level.

In conclusion, I believe that my initial hypothesis was wrong because my limited regression analysis dataset and that a broader statewide evaluation described above could provide more supportive results as literature does show that communities who are impacted by the most environmental harm also experience disproportionate negative socioeconomic impacts. Despite these results, it is clear from my research that overall CalEnviroScreen is a successful, useful tool that enjoys broad support across the spectrum of stakeholder groups and its use is meaningfully advancing environmental justice in California.

APPENDIX A
Table of Regression Articles

Authors & Publication Date	**Data Used: Source & Sample**	**Dependent Variable**	**Explanatory Variable That Measures Environmental Concern**	**Magnitude of Environmental Impact for Statistically Significant Findings**
Linn (2013)	Single-family home sale prices, dates, parcel ID for Cook County from Illinois Department of Revenue merged with assessment data from Cook County Assessor's Office. Brownfield site locations in Cook County, Illinois from US EPA.	Sales price of a property	Property's proximity to a brownfield, property characteristics (land, rooms, air conditioner, exterior, garage, fireplace, etc)	The entry and certification of a brownfield .25 miles away increases property values by 1 percent
Guignet and Alberini (2015)	Stated preferences questionnaire of Italian and British homeowners including demographics and stated property characteristics of survey respondent's homes. Italian and England air pollution exposure data.	Willingness to pay for reduced mortality (measured as VSL: value of statistical life)	Currently affected by air pollution, demographics, property characteristics	Respondents willing to pay premium for homes in areas with lower mortality risk: \$8.5 million VSL in Italy, \$2.8 million VSL in England. Persons who already affected by air pollution willing to pay double that.

Giudice, De Paola, Manganelli and Forte (2017)	Italian government survey of noise pollution levels along Naples Beltway A sample of 46 housing units with similar quality located in the same neighborhood subject to noise monitoring (prices and characteristics)	Property value	Noise pollution levels (as a proxy for environmental externalities: air pollution, traffic, etc), property characteristics	Real estate values are reduced .30 percent for every noise pollution unit
Sullivan (2016)	Sample of LA County housing data for 275,218 sales since 1990 including price and property characteristics Location of firms regulated under RECLAIM program from the South Coast Air Quality Management District Regional air pollution monitoring data from the California Air Resources Board Individual household-level air pollution from AERMOD	Sale price of a property	Several different regression variable scenarios: 1) property value, characteristics, individual air pollution exposure pre-electricity crisis/air pollution improvements 2) property value, characteristics, individual pollution post-electricity crisis/air pollution improvements 3) property value, characteristics, regional air pollution exposure	When using individual air pollution measure, property values increased 1.8 percent on average after air pollution improvements achieved from the electricity crisis When using regional air pollution measure, no statistically or economically significant effect is found
Currie, Davis, Greenstone and	1600 toxic plants in five US states open or closed between 1990-2002	Mean housing value	Toxic plant characteristics (location, open/close dates, economic attributes)	Housing values are about 1.5 percent lower within one mile of operating toxic

Walker (2013)	Housing values and demographics for properties within one mile of each facility		Community characteristics (housing prices, demographics)	plants. Values decrease 1.5 percent at opening, increase 1.5 percent at closing. Aggregate loss in housing value per plant is approximately $1.5 million
Davis (2011)	Sample of 92 power plants opened between 1993-2000 from the US EPA Housing and demographic data for neighborhoods where power plants were opened in the 1990's from the US Census	Housing prices	Power plant characteristics (as a proxy for environmental health), demographic and property characteristics	Compared to neighborhoods with similar housing and demographics, housing prices in neighborhoods within 2 miles of power plants experienced 3-7 percent decreases. Aggregate loss in housing value per plant is approximately $13.2 million Evidence also shows statistically significant decreases in income, educational attainment and proportion owner-occupied in neighborhoods near plants.
Guignet (2012)	Housing prices, neighborhood characteristics, underground storage tank facility locations, leak investigations and groundwater well contamination tests for three	Housing prices	Characteristics/proximity to underground storage tanks, neighborhood characteristics, property characteristics	Home values are not impacted by the presence of a leaking underground storage tank. Home values depreciate 9-12 percent when the property is among homes where the

	Maryland counties from 1996-227			private well is tested for contamination. This is likely because the homeowners have information from the utility.

APPENDIX B
Interview Questions

1. What has been the impact, positive or negative, of using CalEnviroScreen as a tool to address environmental justice concerns in California?
2. What do you believe to be the best uses of CalEnviroScreen to date and best future possibilities?
3. What do you think about using individual layers or indicators for policymaking or funding prioritization?
4. My regression found traffic density to be the only CalEnviroScreen pollution indicator that has a statistically significant negative affect on housing prices.
    a. What do you think about using traffic density as an added screen for prioritizing traffic congestion investments?
    b. What do you think about the overall concept of using CalEnviroScreen data or DAC designation for the purposes of economic development and/or mitigating the negative impacts of pollution to local economies?
    c. What kind of economic development strategies do you think could be targeted at DACs using cap-and-trade dollars or other funds?
5. What do you think are similar applications or uses for individual CalEnviroScreen data layers?
6. What improvements, adjustments or additions would you like to see in future versions of CalEnviroScreen?
7. What other tools or information should policymakers be considering or using in concert with CalEnviroScreen

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