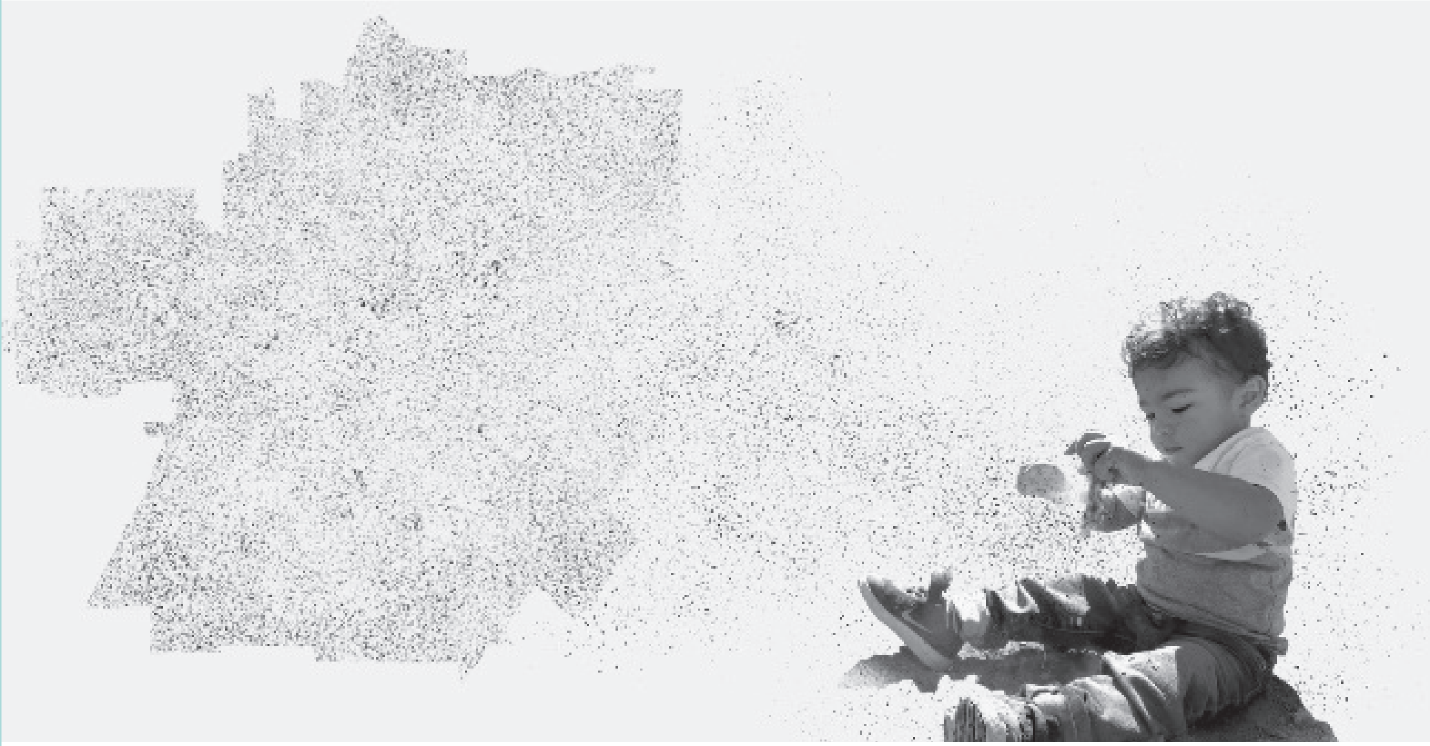
REPORTING ON LEAD CONTAMINATION

A guide for journalists and community members



From the Center for Public Integrity and Grist

The Center for Public Integrity
Grist

About this guide

Lead is a major health threat in communities across the United States and world. But far too little attention is paid to a key way that people, and children especially, get exposed.

This guide will help you shine a light on that in your community.

It's aimed not only at journalists looking to investigate, but also at residents wanting to understand and tackle a solvable problem. I'm Yvette Cabrera, an investigative journalist. I'm sharing what I've learned after eight years reporting on this issue — first for ThinkProgress, then Grist, and finally the Center for Public Integrity — because it's clear that children will keep being poisoned by lead in soil, year after year, if communities don't take action.

In this guide, you'll find detailed information about historical context, ways of finding where lead lurks in your community, the impact of zoning, helpful studies and books, and examples of stories you could tackle as a reporter (or suggest to your local reporters if you're a community advocate). There's also a helpful section from Clayton Aldern, a Grist data journalist who collaborated with me on the lead-focused "Ghosts of Polluters Past" series, that explains how to analyze and visualize lead data.

This information is meant to be shared. Please pass it on to people who would find it helpful.

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Lead 101: The health basics

The accumulation of lead in soil from historic and current emissions is a global crisis that poses a danger to millions of people in urban centers. An estimated 800 million kids around the world, or 1 in every 3, are lead-exposed.

In the United States, the U.S. Environmental Protection Agency has described the nation's lead-poisoning epidemic as the number one environmental health threat to young children. It presents hazards for people exposed as adults, too.

For more than a century, lead has contributed to the inequalities facing communities of color and working-class residents in urban centers across the country.

Most public health care agencies focus on paint and water sources, and identify lead hot spots with blood tests rather than testing the environment. In doing so, they overlook the significant threat in urban soils that experts say is a persistent source of chronic lead poisoning in children.

But in one California city, a coalition of residents, university scholars, and environmental advocates galvanized by my reporting on soil lead contamination are pressing city policymakers to address the problem. And they're succeeding.

Here's why it's important for reporters to write about this public health crisis and for communities to take action:

For more than a century, lead has contributed to the inequalities facing communities of color and working-class residents in urban centers across the country.

In September 2023, the World Bank published estimates of the global health burden and cost of lead exposure, and found that the worldwide toll of lead contamination is immense. In 2019, more than 5.5 million adults died from heart diseases as a result, researchers found. And it's impacting the abilities of many young children.

Chronic exposure to this neurotoxin leads to a lifetime of problems.

Lead is particularly dangerous for young children because it disrupts the brain's growth, leading to irreversible damage in the brain tissue region that controls a person's decision-making skills. This includes the ability to stay focused, make judgments, and plan, according to the research of brain imaging expert Kim Cecil from the Cincinnati Children's Imaging Research Center.

A child plays in the dirt during a groundbreaking ceremony for Santa Ana, California in 2017. (Grist / Daniel A. Anderson)

Long-term studies have also shown the link between brain damage from lead exposure and adult crime. Lead's impact on executive functioning skills can lead to a lack of impulse control, harming a person's ability to delay gratification and think about the future.

Lead exposure can also affect a child's ability to learn, lowering school test scores and impacting academic achievement.

Because a majority of lead settles in our bones, childhood lead exposure can have generational consequences. A pregnant mother transfers that stored lead, which mimics calcium, to the fetus as it develops in utero.

One recent study that examined the impact of leaded gasoline emissions in the United States found that half the U.S. population was exposed during childhood to harmful levels of lead, resulting in a massive loss of IQ points. This translates to an estimated 170 million Americans alive today who were exposed to high lead levels as children, primarily those born between 1951 and 1980, the researchers from Florida State University and Duke University found.

"The scope of such widespread exposure ... suggests the legacy of lead continues to shape the health and well-being of the country in ways we do not yet fully understand," the authors of the report noted.

Soil lead contamination

If you work in a major urban center, there's a strong likelihood that you'll find lead contamination in your city's soil, particularly the inner core. But as I discovered in Santa Ana, California, as part of a 2017 investigation, smaller cities also face soil lead hazards.

Scientific studies have shown the pervasiveness of soil lead contamination across the United States in urban centers, which remain highly contaminated by lead due largely to the past use of leaded gasoline and paint, as well as past and present industrial pollution. This lead dust from urban soils is more toxic, potent and concentrated than lead that naturally occurs in the soil.

Studies of tests measuring lead levels in children's blood have also found seasonal spikes in the summer and fall — when kids spend the most time playing outside. That shows the problem extends beyond common indoor culprits like leaded paint.

If you're interested in investigating soil lead contamination in your city, start by checking whether local universities or local agencies have tested the soil already. Here are a few examples of academic work on the topic:

This 2018 study created the first comprehensive map of soil lead in New York City. A 2020 study found that median concentrations of soil lead — and the rates of young children with elevated blood lead levels — were twice as high in redeveloped areas of New York City with a history of industrial and manufacturing land use, polluting facilities and more roadways.

Soil lead expert Howard Mielke, an urban geochemist and health expert from Tulane University, has spent four decades investigating the dangers of lead contamination in soil across the country. He has geographically mapped lead soil levels in Baltimore, New Orleans, Minneapolis-St. Paul and other Minnesota cities.

In cities like Flint, Michigan, where the lead water crisis focused attention on the dangers of lead pipes, research has shown that soil exposure is likely also playing a role in children's elevated blood lead levels. Community groups like Edible Flint have tested soil in gardens for lead and other contaminants. More extensive testing throughout the city could illuminate where soil hotspots are located.

For an overview of existing soil lead tests in areas around the country and world, check out the online portal Map My Environment, which maps the soil test results of scientists, residents and others. Gabriel Filippelli, a biogeochemist who has studied lead contamination for more than two decades, helped create this online platform visualizing the data, including lead levels in soil, dust and water. The site also offers recommendations on how to remediate lead.

Indicators

There are indicators of current and past sources of soil lead contamination that can help you narrow down whether (and where) to investigate the problem in your city. These include leaded gasoline emissions, the age of housing stock to determine whether leaded paint was predominant, and the industrial history of a city.

Leaded gas use peaked during the mid-20th century. But because lead is a persistent pollutant, doesn't decompose, and its use was so widespread, it's likely still in the environment surrounding highways and major thoroughfares.

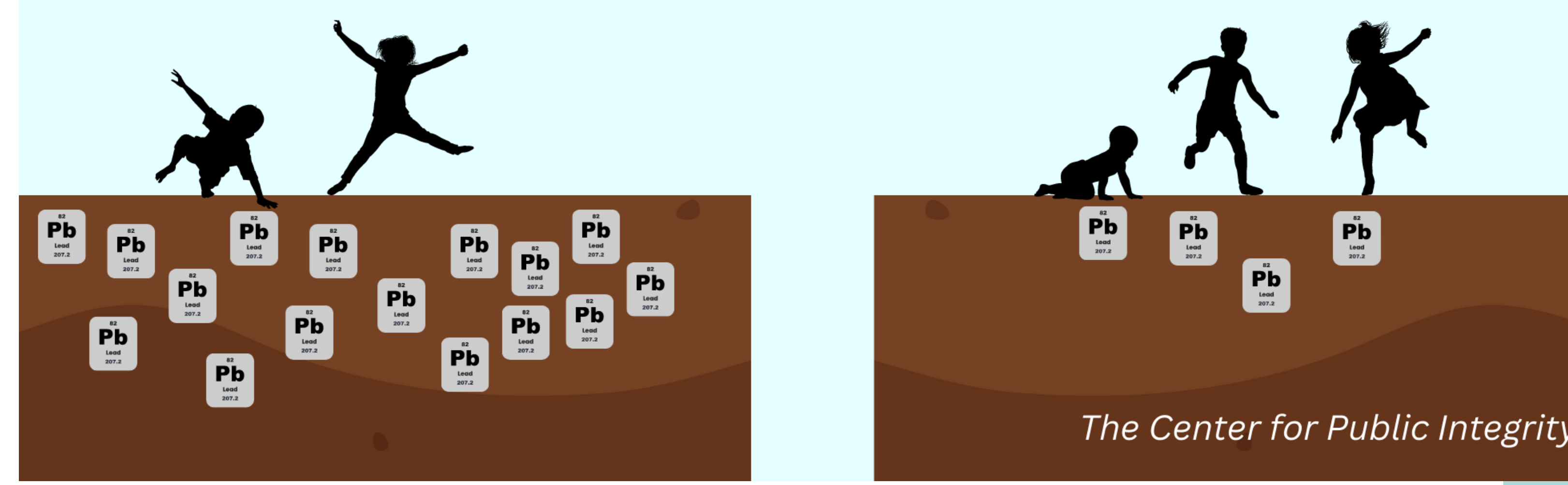
Lead emitted as air pollution accumulates in soils and can remain there for hundreds of years, according to Mielke and other experts. Mielke's research on lead in New Orleans has shown that at least five to 10 times more lead dust comes from lead gasoline additives compared to leaded paint, with the highest concentrations of dust found in the high-traffic-flow areas of the inner city. (Lead tests can distinguish between the type in gas versus paint.)

This 2010 study, which estimated the amount of lead dispersed by leaded gasoline use in eight California cities, could help you

How rules to protect kids from lead fall short

The EPA's definition of a "soil lead hazard" is 400 parts of lead per million parts of soil in areas children play ...

... but much lower levels are also dangerous. Even under 100 ppm, lead harms the brain.



Understanding the history of leaded paint use is key to determining which neighborhoods face the greatest threat based on the age of homes.

determine whether your city might still be impacted by legacy lead contamination. The researchers found that although soil lead mapping exists for some of California's urban areas, they are not extensive. The cities featured in the study are Bakersfield, Oxnard-Ventura, Sacramento, Riverside-San Bernardino, San Jose, San Diego, San Francisco, and metro Los Angeles.

This 2010 article expands on that work and provides a list of cities ranked by the estimated amount of lead additives in gasoline used in 90 U.S. urban areas. The Los Angeles-Long Beach-Santa Ana region in California ranked number one on the list, followed by New York-Newark and Chicago.

In California, a 1992 report from the Centers for Disease Control and Prevention, or CDC, provides an overview of surveys conducted by the California Department of Health Services, which found alarming levels of soil lead in various cities throughout the state. In Oakland, for example, 46 percent of residential soil lead levels exceeded 1,000 parts per million, far above the current 80 ppm level that the California Office of Environmental Health Hazard Assessment considers dangerous for children in residential areas. Other areas surveyed by the state, which measured blood lead levels, household paint, and soil, include Wilmington and Compton in Los Angeles County, and Sacramento.

Although the federal government banned lead-based paint in residential homes in 1978, those who live in older, dilapidated homes with flaking and chipped paint face a higher risk. Children especially can be exposed outside as well as inside, because the flakes, dust, and chips from outdoor paint contaminate the soil. Understanding the history of leaded paint use is key to determining which neighborhoods face the greatest threat based on the age of homes.

This study provides a helpful overview of lead exposure sources in the United States, including the history of lead paint use. The report notes that white lead was used for both interior and exterior paints. On average, interior paints prior to 1940 were about 50 percent lead.

Another helpful point in the historical timeline that the researchers cite: Lead use in residential paint was unregulated until 1955. That year, the paint industry adopted a standard for paint used in interiors of no more than 1 percent lead by weight. The report notes, however, that leaded paint continued to be used into the early 1970s for exterior paints and primers, and to paint cars and metal structures, for example.

To track the age of housing, go to the CDC National Environmental Public Health Tracking Network website, which includes health and environmental data from a variety of sources (national, state, and city). You can find data about hazards, health effects, and population health.

For example, if you'd like to see the percentage of homes built before 1950 in California by census tract, you can input that and find the counties — Los Angeles, Ventura, Santa Barbara, and San Bernardino — with the highest percentage of these homes. The tool will also tell you the number of homes this represents.

Testing the soil

Simply understanding the likelihood of soil lead contamination in your community can help you shine a light on the problem.

But if you have time to go deeper, you can show exactly what your community is facing.

I decided to begin testing the soil in Santa Ana in 2015. At the time, there wasn't any publicly available local or state data that could show whether the soil might be contributing to children's elevated lead levels in the city.

First, I spoke with investigative reporter Alison Young, who did a groundbreaking USA Today series on lead contamination. She and her colleagues tested the soil around abandoned lead smelters for this project, and she generously explained the process they used.

Ultimately, I followed the steps that Alison recommended: to test onsite with an x-ray fluorescence, or XRF analyzer, and also to collect dirt samples and send them off to be analyzed in the laboratory run by Mielke, the Tulane expert, to confirm the accuracy of the field tests.

A representative from Massachusetts-based Thermo Fisher Scientific trained me to operate an XL2 600 Niton x-ray fluorescence analyzer, which produces x-rays to measure the lead content of soil. The company loaned me the XRF analyzer and calibrated it for soil testing.

For the two lead contamination investigations, I tested more than 1,600 soil samples throughout Santa Ana. I followed a protocol recommended by Mielke to test along linear east-west and north-south paths at half-mile intervals across the entire city, in addition to testing that I conducted in the city center and other neighborhoods around the city.

A majority of the tests were done in residential yards with the written permission or verbal consent of the occupant. The remaining 10 percent were conducted in public spaces, such as street-side right-of-ways, playgrounds, parks, and bike trails.

I conducted the testing on bare soil throughout residential yards with a focus on areas where children play. I also tested soil along the perimeter of the yard near fences, as well as the area close to the outer wall of a building.

As part of an explainer that ran with the investigation, I outlined the results of my tests, the average margin of error, and how I conducted the effort. For example, I discarded any soil tests with incomplete scans, which could be caused by disruptions that produced a movement of the XRF analyzer during analysis. I also explained that the XRF and these particular laboratory tests measure the amount of lead in the soil but do not determine the source of the lead.

Additional soil resources

Connecting with experts will help you. As I've conducted my soil lead investigations, I've had the opportunity to talk to such people as Simon Fraser University professor Bruce Lanphear, an epidemiologist and leading expert on early childhood exposure, and others who explained the health and regulatory standards on soil lead exposure.

Here are a few studies that might help you as well:

This 2019 review of two decades of research on lead in U.S. soil, dust, water, food, and air provides helpful findings. The average level of lead in residential soils is three times higher for urbanized areas than non-urbanized areas, for example. The study also outlines shortcomings in data; research for environmental lead concentrations at schools and daycare sites is limited.

This 2017 article examines approaches to address urban soil contamination and reduce exposure. This includes small-scale pilot studies and programs to isolate lead in soil, as well as the effectiveness of soil lead remediation in reducing exposures and blood lead levels in children.

In cities such as New Orleans and New York, researchers have found that one of the most effective ways to protect people from lead exposure is to cap contaminated soil with clean soil. This 2022 article outlines those approaches and the results, which indicate that blood lead levels are "powerfully influenced" by reducing soil lead. And this series of articles outlines key research findings, including the influence of soil lead contamination on children's health, pathways of exposure, and interventions that work.

Other studies, like this one on soil lead in New Orleans, examine neighborhood inequities by soil, children's blood lead levels, race, and income, while this report examines the role of topsoil depletion in declining blood lead levels of children in New Orleans.

In New York City, soil expert Sara Perl Egendorf saw that residents weren't sure how best to protect against soil lead contamination in urban gardens. So Egendorf helped create a network called Legacy Lead to help residents tackle it. She also co-authored a free digital illustrated book.

Accessing data on lead in blood

Public health agencies across the country test children's blood for the presence of lead. No amount is safe, research has found. But agencies often don't suggest there's a problem unless a child's levels are above 3.5 micrograms of lead per deciliter of blood, the point at which the Centers for Disease Control and Prevention recommends public health intervention.

This data can help you show where kids are getting exposed across the United States. Keep in mind, though, that most studies reveal a vast undercount and underreporting of blood lead levels in states across the country.

Accessing data from state and local public health care agencies about the levels of lead found in children's blood can be a challenge because these agencies often cite the federal HIPAA law to deny public records requests. The law protects personally identifiable patient health information from being disclosed without a patient's consent or knowledge.

But it is possible to obtain data that doesn't require the disclosure of personally identifiable details. Blood lead level by census tract, for instance. That's what Reuters did in this 2016 investigation that found elevated blood lead hot spots across the country.

In California, I was able to obtain blood lead levels by ZIP code for Santa Ana and other Orange County cities. That allowed me to compare the much higher percentages of children with elevated levels in Santa Ana's ZIP codes compared with the rest of Orange County.

I first searched for existing online data. There was very little specific to Santa Ana in early 2015 when I began my investigation. I found an Orange County Health Care Agency Childhood Lead Poisoning Prevention Program newsletter from 2011 that listed local cities with the most number of children with elevated blood lead levels. Santa Ana was at the top of the list. But the data was aggregated for a five-year period (2006 through 2010) and didn't provide yearly totals or other details.

A California Department of Public Health online database at the time contained only county-level totals for these tests. The data was incomplete, listing blood lead levels from 2007 to 2011, but missing data from 2012 to 2014. It also lacked city-level data.

The CDPH office of public affairs was responsive and helpful regarding my requests for more data. Initially, they provided Santa Ana citywide blood lead level data for the years available at the time (2007 to 2012) for children who tested above 4.5 micrograms per deciliter. When I asked for more context, such as how many total children were tested every year and how many children had lead levels at higher thresholds (above 9.5 micrograms per deciliter), CDPH provided that as well.

But as I began testing Santa Ana's soil in the fall of 2015 and started finding higher lead levels in some parts of the city, I realized I needed more granular blood lead data as well as clarity around any findings from state or county investigations into potential lead sources. The CDPH told me that Orange County had conducted 71 environmental investigations over a five-year period to inspect for lead, but the state agency couldn't provide more specifics and directed me to the Orange County Health Care Agency for answers.

I spent the next year emailing and speaking to both agencies in an effort to understand how many of those investigations were conducted in Santa Ana, what ZIP codes they were conducted in and whether anyone could give me blood lead level data by ZIP code for Santa Ana.

The county health department's initial response was that they could not provide ZIP code data on the environmental investigations due to HIPAA. But ultimately, they clarified that out of 16 environmental investigations they conducted from 2013 to 2015, only three were done in Santa Ana.

In the summer of 2016, the California Department of Public Health at last provided a breakdown of childhood blood lead level data by ZIP code for Orange County, along with the top 200 California

ZIP codes for children with levels at and above 4.5 micrograms per deciliter in 2012. The agency also provided a dataset that included elevated blood lead levels by city for all of Orange County in 2015.

The state noted that this was a newly completed analysis. When Reuters published its investigation in December 2016, its blood lead level maps included California. I couldn't help but wonder whether the pressure of a large news organization like Reuters requesting the same type of blood lead level data I was asking for created an incentive for these public health care agencies to comply with our data requests.

Because some states do place limitations on releasing such data and cite HIPAA in doing so, I recommend that reporters partner with other news organizations to file these public records requests. (Community advocates, meanwhile, might want to partner with other groups or academics.) In making my case to Orange County health officials at the time, I pointed out that data I sought at the ZIP code level would not violate anyone's confidentiality. Rather, it would be a public service to help residents understand lead hotspots in their neighborhoods.

Ultimately, this data allowed me to publish a series of maps with my first soil lead contamination investigation in 2017. It showed Santa Ana residents which ZIP codes had the highest childhood blood lead levels.

Soil lead expert Sara Perl Egendorf works with residents throughout New York City to protect their health by covering contaminated soil with clean soil. (Ilexis X. Chu-Jacoby)

Industrial history

A 1964 aerial view of the Greater Logan Area, looking south from the Santa Ana water tower. (Courtesy of First American Title Insurance Company)

The more you know about your community's industrial past, the better you can understand current-day lead contamination.

To learn about the industrial past of neighborhoods in Santa Ana, I adopted the methodology created by sociologists Scott Frickel and James Elliott and outlined in their 2018 book *Sites Unseen: Uncovering Hidden Hazards in American Cities*. My goal was to catalog the accumulation of defunct industrial sites in Santa Ana, what Frickel and Elliott describe as "relic sites," to understand the types of businesses that churned through the neighborhoods and the sorts of products and pollutants they produced.

I did this by scanning manufacturing business directories published decade after decade. The directories list business addresses, the products that were produced, the number of people employed and, most importantly, what are known as Standard Industrial Classification, or SIC, codes. These four-digit codes are part of a federal classification system that categorizes business sectors.

Frickel and Elliott focused on hazardous industrial sectors, determining when these businesses operated to show how urban land becomes industrialized, then later reused for other purposes, its past forgotten — resulting in contamination that's never cleaned up.

That's the process my colleague, Grist senior data reporter Clayton Aldern, and I replicated to understand when these businesses operated in Santa Ana. I did the front-end work: tracking down the directories and, for at least one directory per decade across a span of six decades, scanning the pages for the city of Santa Ana.

Most states have published directories documenting industrial businesses since the mid-20th century. They are found under different titles depending on your state: for example, the *Louisiana Industrial Directory* or *Minnesota Directory of Manufacturers*. The directory I used is called the *California Manufacturers Register*.

Hunting them down can be a challenge. Frickel and Elliott found that as storage space shrinks, libraries archive the books in off-site repositories or even dump them.

But they do exist, and I felt like I struck gold every time I located one online. You'll most likely find them in university libraries, state libraries, local public libraries, and state historical societies. I was even able to order one on Amazon. Local county and city archives also preserve city directories, which can be used to locate businesses for years prior to 1950 or to track businesses as they moved from one part of a city to another.

I found the oldest *Directory of California Manufacturers*, from 1948 (sadly without SIC codes), at the California State Library in Sacramento. The biggest trove of directories I came across is at California State University, Fullerton. Others turned up at the University of California, Santa Barbara, as well as a public library in Santa Cruz. Here are a few examples of the online search results for CSUF and the California State Library.

I visited the libraries in person, and since I didn't have a library card for each

The more you know about your community's industrial past, the better you can understand current-day lead contamination.

of them, I spent days at a time scanning the pages using the Scanner Pro app and uploading them into Google folders. The process is tedious, as the directories list businesses in alphabetical order for each city. Each business must be located within its category sector in the directory and scanned. It's that page that contains the name, address, and details, such as what products were manufactured.

For a detailed explanation on how to find relic sites in your city, Sites Unseen has a very helpful DIY guide in the appendix that offers tips on how to track down directories in your state, compile historical sites of interest, and map these sites.

At Cal State Fullerton, I enlisted the help of a handful of students I met during a presentation on my lead contamination reporting for one of the classes of Erualdo González, an urban studies professor there. The students received class credit from González and a Starbucks card from me (as well as reimbursement for the scanner app) for helping.

I then hired another data reporter, Uriel Garcia, to upload my scans onto Excel sheets and create a database of all the businesses by year. Clayton then tapped this database to map the businesses to show the contribution of historic industrial emissions over six decades in Santa Ana, an important part of what became our "Ghosts of Polluters Past" series.

Ultimately, what we found is that these California directories from as far back as the 1960s recorded nearly 2,000 manufacturing sites — in industries like plastics, fabricated metals, and chemicals — throughout the last half of the 20th century in Santa Ana. More than 300 were active as of 2014, the most recent directory we analyzed. These were businesses that might never have had their toxic footprints cleaned up if they operated prior to creation of laws and regulations requiring remediation of contaminated lands.

This type of effort can help you understand your community's toxic footprint, not only for lead but for other contaminants as well.

Zoning, land use and racial covenants

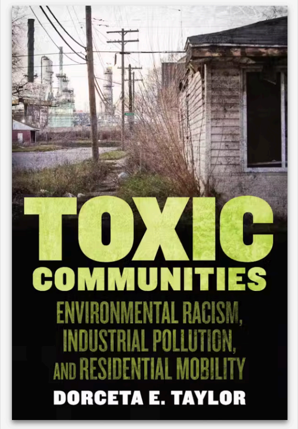
One legacy of widespread 20th-century policies such as housing segregation and discriminatory zoning and land-use decisions: Marginalized communities have higher exposure to lead contamination. These practices cause health and economic disparities among the working class and residents of color who have lived for generations in polluted neighborhoods that are physically and symbolically on the wrong side of the tracks.

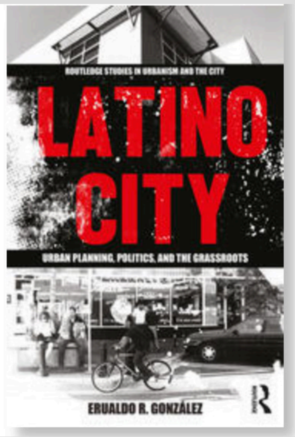
Zoning

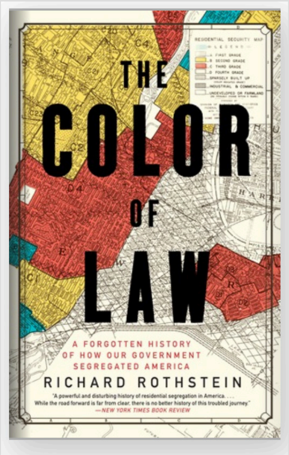
Reconstructing past land-use and zoning decisions by municipal agencies can help communities understand the role they played in creating a city's current ecological and built environment. An example would be the decisions that allowed mixed use or industrial zoning near residential areas. Housing segregation via the use of racial covenants can also illuminate how certain racial, ethnic, and religious groups were prohibited from living in neighborhoods distanced from industry, where the air was cleaner and the environment healthier. (More on covenants shortly.)

In Santa Ana, many key zoning decisions were made in the early- to mid-20th century, during an era when documents were not always preserved or are challenging to find now in digital format. You're more likely to find what you're looking for in public libraries, university

Books on this topic







A barbed wire barrier hangs over a wall separating an industrial business and the residential yard of a home in Santa Ana's Logan neighborhood. (Daniel A. Anderson for the Center for Public Integrity)

archives, and government archives. The Santa Ana city library's history room had a trove of planning department and planning commission documents that outlined key zoning decisions.

The Santa Ana Planning Commission's records in the history room showed that commissioners were strategically approving and denying zone changes that placed a heavier industrial burden on the city's eastside barrios near the downtown central core, where many Mexican and Mexican American residents lived. One 1929 document showed that the commission, which later rezoned a portion of the eastside Logan barrio for heavy industrial use, was pressured to do so by the Santa Fe Railroad and Richfield Oil companies.

Librarians can be critical guides on this journey. I was aided throughout my research by then-Santa Ana History Room librarian Dylan Almendral, who was helpful in outlining what records might help answer my land-use questions and pointed me to outside experts as well.

Local and national zoning experts can give you the context behind zoning decisions. *Noxious New York: The Racial Politics of Urban Health and Environmental Justice* by Julie Sze, a professor at the University of California, Davis, was not only helpful in outlining the factors that led to New York City's zoning code and the impact on working-class neighborhoods, but her work also led me to another zoning expert, Juliana Maantay.

Maantay, a professor of urban environmental geography at the City University of New York's Lehman College, has studied urban zoning, equity, and public health impacts globally. Her research is extensive, but here are two of her reports that helped me understand the ramifications of zoning on public health and the environment: "Zoning, Equity, and Public Health" and "Industrial Zoning Changes in New York City: A Case Study of 'Expulsive' Zoning."

University of Michigan professor Dorceta Taylor's book *Toxic Communities: Environmental Racism, Industrial Pollution, and Residential Mobility* is another excellent resource. Several chapters focus on the disproportionate siting of industrial uses as well as the rise of racial zoning.

And don't forget to tap into local knowledge. I relied heavily on the expertise of longtime Santa Ana residents in the neighborhoods where I focused my reporting. These residents authored books, served as leaders of their neighborhood associations, and were long-time activists who were extremely knowledgeable about the zoning history and land-use decisions made by the city across decades. Their historical records (news clips, photographs, and archival documents) as well as their memories of important city votes and decisions aided me as I did my research to confirm key planning commission decisions.

Reconstructing past land-use and zoning decisions by municipal agencies can help communities understand the role they played in creating a city's current ecological and built environment.

Oral history archives can be another helpful resource. Josephine Andrade, one of the most well-known Logan barrio activists and community leaders, died in 2006, but her thoughts on major zoning decisions were preserved thanks to a 1982 oral history interview stored at the Lawrence De Graaf Center for Oral and Public History at Cal State Fullerton. In the interview, Andrade described how the Logan barrio residents were caught off guard when the city first zoned the neighborhood as industrial in 1929. Many residents only learned about the decision when a sign was posted in the neighborhood after the fact, she said.

I found out about Andrade's oral history interview thanks to a book written by González of Cal State Fullerton: *Latino City: Urban Planning, Politics, and the Grassroots*, which explained the redevelopment of Santa Ana over a 40-year period starting in the early 1970s. Local experts who understand the political clashes and conflicts at the local level are invaluable, particularly when they approach their work through a lens of equity and justice, as González does. Knowing the key community leaders, city officials, and neighborhood dynamics meant he could provide both an academic perspective as well as an understanding of the aspirations of residents who wanted urban policies that would improve their community.

Lastly, don't overlook dissertations. They can be invaluable in referencing key land-use decisions and often include interviews with local residents and insights that can get overlooked in official city reports.

The 1985 dissertation of historian Lisbeth Haas was crucial to my reporting because her research on Santa Ana's barrios, including Logan, focused on a period of Mexican American history in Santa Ana, from 1850 to 1947, that typically isn't found in mainstream history books. She not only made herself available for an interview, but also pointed me to other publications and work she's done on Santa Ana. I especially appreciated a rare 1927 barrio map of Santa Ana in her dissertation that showed early boundaries for these neighborhoods.

Racial covenants

Racial covenants were used hand in hand with zoning codes to force marginalized residents into certain neighborhoods within a city. The segregation they produced persists to this day.

Racially restrictive covenants were clauses placed by homeowners or developers in residential deeds to prevent Blacks, Mexicans, and other people of color from living in those properties.

Segregated neighborhoods were often divided, such as via the construction of freeways through historically Black neighborhoods. And industrial zoning was often concentrated in neighborhoods within the inner cores of cities — areas that did not have racial covenants and where people of color were allowed to live.

The accumulation of pollutants from historic and current industrial sites poses a danger to today's residents if left unremediated.

The accumulation of pollutants from historic and current industrial sites poses a danger to today's residents if left unremediated.

If you're reporting in a smaller city such as Santa Ana, you're more likely to find evidence of the use of racial covenants, rather than redlining, the discriminatory federal effort that was more prevalent in larger cities.

Indeed, the Santa Ana history room librarian did not find evidence that the city was redlined, but Orange County archivist Susan Berumen searched for and found evidence of half a dozen racial covenants in Santa Ana. The earliest racial covenant was part of a grant deed signed in 1921, while the latest in the archival records was signed in 1943, just five years before the U.S. Supreme Court ruled such covenants unenforceable. The court declared in that decision: "Equality in the enjoyment of property rights is an essential precondition to the realization of other basic civil rights and liberties."

To understand more about the lasting effects of racial covenants, go to the University of Minnesota's Mapping Prejudice website. That was the first comprehensive spatial database and map of racial covenants for an American city. The project mapped nearly 25,000 early-to-mid-20th century racial covenants in Hennepin County that show how this form of structural racism, although long outlawed, embedded into the built environment and continues to shape inequality across the county.

A helpful resource for understanding redlining is the University of Richmond's Mapping Inequality: Redlining in New Deal America website. Redlining refers to the grades that the federal Home Owners' Loan Corp. issued regarding the risk for banks and mortgage lenders doing business in different neighborhoods. The agency created maps showing these grades, with those categorized as "hazardous" colored red. Neighborhoods of color were systematically redlined, cutting them off from equal access to mortgages.

To learn more about redlining history, check out the excellent book *The Color of Law: A Forgotten History of How Our Government Segregated America* by Richard Rothstein.

Finding visual sources

When researching past industrial or commercial uses of city lots or parcels, having photographic confirmation is helpful not just for reporting purposes, but also for the visual presentation of the story.

While researching the development of one neighborhood in Santa Ana, the Logan barrio, I tapped the treasure trove of photographs at the First American Title Insurance Co. archives in Santa Ana. I used historical photographs to confirm the location of industrial businesses in the Logan barrio, and to get a sense of the conditions in Santa Ana neighborhoods throughout the 20th century.

First American offers public access to its archive of more than 12,500 historical photographs for free to the public. Because the collection is organized primarily by Orange County cities, I was able to review binders dedicated to Santa Ana and found a variety of aerial photographs of Logan and its surrounding neighborhoods. I provided photo credit to First American as required by its policy when a photo is printed in a publication.

The National Park Service's National Register of Historic Places database is helpful when you're searching for neighborhood and home descriptions of bygone eras. I used it to search for details about homes within Santa Ana's neighborhoods. The Logan barrio, which was the focus of "Ghosts of Polluters Past," was mentioned in one document about original home styles (Victorian) in Logan, and how the neighborhood gave way to industrialization in the 1940s.

This was part of a document submitted to nominate a nearby neighborhood for the National Register of Historic Places, but it offered broad details for that eastern section of the city, such as historic boundaries for surrounding neighborhoods and how those neighborhoods developed.

And don't forget about local libraries. The Santa Ana Public Library's history room has a trove of books, photographs, city directories, news clippings, newsletters, and other historic items that are useful when piecing together neighborhood histories. The online photo collection includes historic photographs from the city's Latino neighborhoods, including the Logan barrio.

Also helpful as I researched how the city's barrios developed over time was the history room's small stack of Sanborn fire insurance maps, prepared for locations across the country. Published by the Sanborn Map Co., these maps documented the location of businesses, homes, schools, and other important buildings in the city, and came with a street index, keys, and legends that explained minute details such as the type of material used to construct a building (brick or tile, for example).

The Sanborn Map Co. published these maps for more than 10,000 communities, but today original copies are difficult to find. However, the Library of Congress has digitized versions that can be searched here in its digital collection.

These maps allowed me to identify businesses that were located in the Logan barrio, as well as the location of the barrio's former elementary school that was replaced by various commercial businesses, including a paint shop and tow truck business. The 1959-1960 Sanborn map notes that one section of the Logan barrio was occupied entirely by Mexican residents.

Local residents were also a key source for photographs and historical details. Logan barrio native Mary Garcia not only provided both in her book *Santa Ana's Logan Barrio: Its History, Stories, and Families*, but she also provided copies of unpublished photographs that detailed locations of former businesses and landmarks.

Your state may also have databases that can help you. The California Department of Toxic Substances Control's EnviroStor tool tracks the state's investigations at hazardous waste facilities and sites that are known to be contaminated or where there is evidence of potential contamination.

The database offers details about the history of the site, enforcement actions, and what the investigations uncovered. The database is searchable by city and by business, and includes reports that detail clean-up efforts, inspections, and the history of the parcel use. These reports include photographs of the site as well.

For example, this report for a Santa Ana electronics company that manufactured printed circuit boards from the 1970s to 2013 details how the state agency investigated and detected volatile organic compounds in the soil and groundwater.

A vintage photo of Shell Oil fuel storage tanks in Santa Ana's Logan neighborhood near the original Santa Fe train depot. (Photo courtesy of Mary Garcia)

Story ideas

The deeper I dug into soil lead contamination, the more I realized that it's everywhere. Decades of use in everything from bullets to car batteries, aviation fuel to car fuel, has allowed it to pervade every aspect of our urban lives and environment — so much so that America's cities have become "veritable lead mines," as Christian Warren wrote in his excellent book *Brush With Death: A Social History of Lead Poisoning*.

There are many potential stories to write about historically deposited lead contamination, including from products like gasoline and paint.

But some sources — from secondary lead smelters to small aircraft — are emitting yet more lead today. They tend to be underreported when it comes to the contamination they cause in surrounding neighborhoods.

A few examples of stories you can pursue (or suggest to local journalists, if you're not a reporter):

- **What do experts say?** A Q&A or other story featuring a local or national expert on lead exposure via environmental contamination can offer helpful insights. What work are they doing that's relevant for people in your community? How could your community address lead problems, in their view?
- **Who's trying to help?** Find people in your community who are working to address soil contamination. What barriers do they face? What partnerships are they building? (See, for example, the collaborative efforts by people in Santa Ana.)
- **Does your community have new sources of lead contamination?** You can look at EPA's Toxics Release Inventory and any pollution-inventory reports from your state to find certain types of sources, typically larger. And see below for details about aviation. Academics, environmental groups, and others focused on pollution can be helpful as you get your arms around current-day lead sources.
- **What historical sources of lead contamination still haunt your community?** As this guide notes, there are a variety of methods for finding these sources. Don't forget about major roads built before the 1960s and long-shuttered industrial sites.
- **What's the government doing?** Find out how local and state agencies, such as those focused on health or the environment, are approaching lead risks. Are they taking action on soil, or are their efforts aimed solely at paint and water? Are they working to remediate historical sources of lead? Are they addressing new sources?
- **Who's most affected?** Once you know where lead most likely (or definitely) lurks, you can show who in your community is bearing the heaviest burden from this contamination. What action do people in the most affected neighborhoods want to see? What actions are they taking?

More information that can help you identify lead sources and stories:

If your city has a general aviation airport, you can investigate whether leaded aviation emissions are polluting nearby areas. There are roughly 170,000 piston-engine aircraft estimated to be in use across the country, and nearly all burn a grade of aviation gasoline, commonly referred to as avgas, that contains lead.

These aircraft include airplanes and helicopters used for myriad purposes — including fighting wildfires, agricultural crop dusting, pilot training, medical transport, search and rescue, pipeline inspections, and law enforcement — that operate out of more than 13,000 airports. These aircraft represent the largest single source of new lead air emissions in the country, according to 2017 data from EPA.

The agency, which regulates emissions from aircraft and the use of lead in gasoline, announced in late 2023 that it had classified leaded aviation gasoline air pollution as a danger to public health and the environment. That means the Biden administration is working on new aviation fuel standards to protect communities, but that process can take years.

In the meantime, at least one locality, Santa Clara County, has banned the sale of leaded aviation fuel at its airports. And in early 2024, a new bill was making its way through the California Senate, which if approved would ban the sale of leaded aviation fuel in disadvantaged communities throughout the state by 2026.

This EPA webpage offers a helpful explainer of leaded aviation fuel, as well as fact sheets on air quality monitoring at airports, estimates of lead concentrations at airports, and estimates of the number of people who live near or attend school near airports.

One study commissioned by Santa Clara County found that the continued use of leaded aviation fuel has increased blood lead levels in children living nearby, particularly those within a half-mile of an airport in San Jose. Research has shown that reducing piston-engine aircraft traffic fueled by leaded gas would generate massive societal benefits, increasing children's lifetime earnings.

And then there are lead bullets. A 2017 Environmental Health review article outlines the dangers from lead dust at firing ranges. When a person fires their weapon, lead fragments and fumes are discharged at high pressure. The shooter then inhales or swallows these harmful emissions.

The researchers found that millions of people are exposed to this lead dust: about 1 million U.S. law enforcement officers who train at indoor firing ranges and 20 million people who practice target shooting. The study found that there are between 16,000 and 18,000 indoor firing ranges across the country.

If you want to delve deeper to spark more ideas, here's a sampling of helpful books — in addition to *Brush With Death* and those mentioned in earlier sections — that shed light on widespread lead use and the policy decisions that allowed it:

- *Lead and Lead Poisoning in Antiquity* by Jerome O. Nriagu
- *Lead Wars: The Politics of Science and the Fate of America's Children* by Gerald Markowitz and David Rosner
- *Toxic Truth: A Scientist, a Doctor, and the Battle Over Lead* by Lydia Denworth

Grants and fellowships

Tackling lead contamination as an enterprise or investigative story takes time and resources. When I first began investigating this issue, I was a freelancer, so I applied for grants to support my soil testing work, research, and reporting. Here is a list of some of the organizations that supported my work, as well as others currently offering financial grants and editorial support for journalists seeking to take on in-depth reporting projects:

The Fund for Environmental Journalism, run by the Society of Environmental Journalists, provides grants that support coverage that otherwise would not be completed. The grant can be used to develop a story as well as disseminate it — for example, through travel, multimedia production, or translation work. I received an environmental justice grant to pay for the cost of creating a database (of industrial and commercial businesses) as well as fact-checking for my lead investigation. Grant topics vary and can be tracked on the SEJ website. If you're interested in receiving information about future grants, you can sign up here.

The National Press Foundation and the National Press Club Journalism Institute jointly offer grants to U.S.-based journalists covering environmental justice issues. These Kozik Challenge Grants support journalism work in any medium that centers on environmental justice or environmental racism. I used this grant to cover my on-the-ground reporting travel expenses as well as soil testing. To learn about upcoming grants and resources, you can sign up for the NPF's newsletter here.

The Fund for Investigative Journalism provides a wide array of grants to journalists from all mediums to support impactful investigative reporting. This includes freelancers and staff reporters who produce investigations for print, online or broadcast as well as books, documentaries or podcasts.

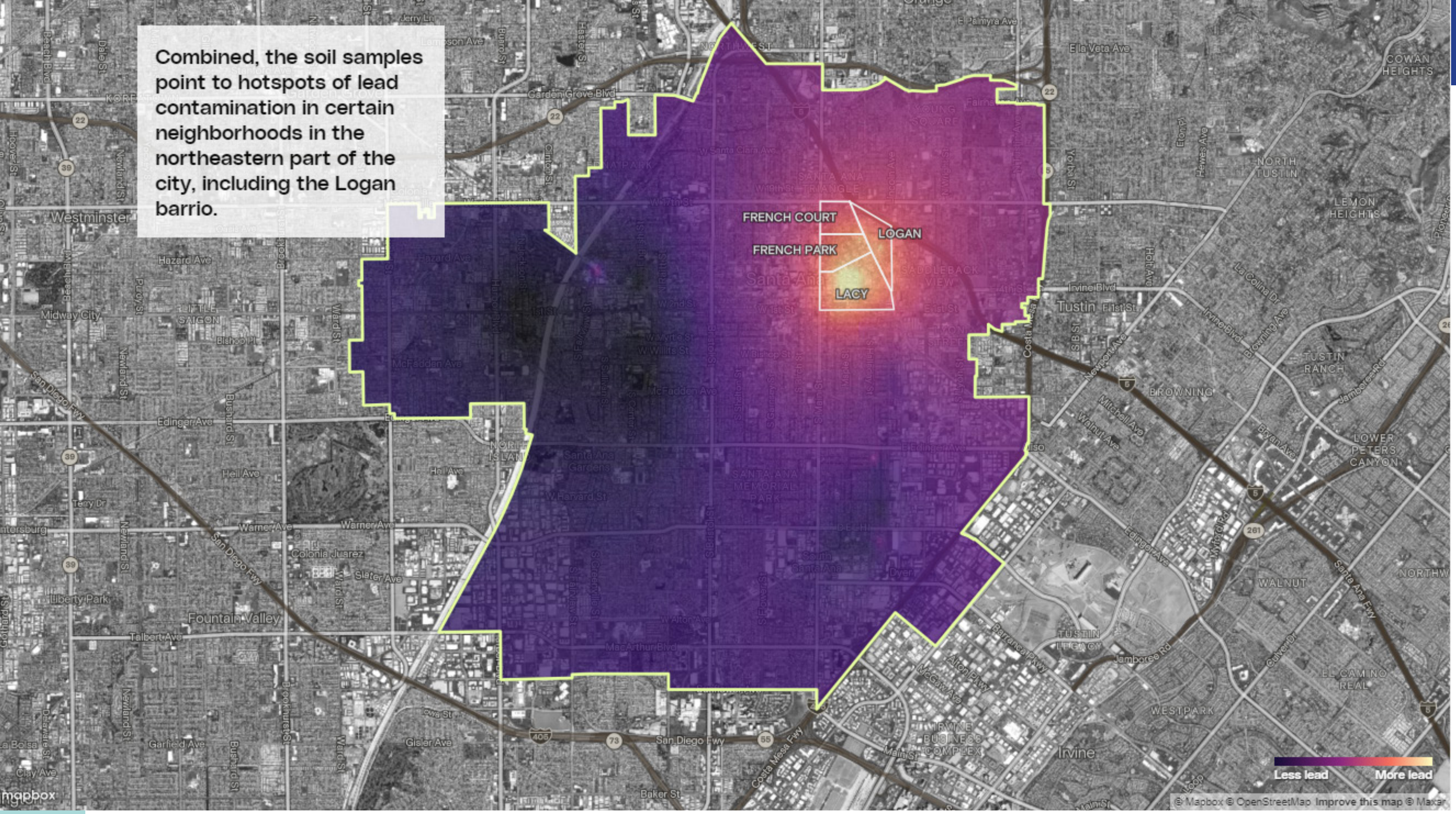
There are also fellowships that aren't focused on environmental coverage specifically, but could be applicable when an environmental issue, such as lead contamination, intersects with the fellowship topic (for example, health, education, or juvenile justice). In 2015, I received a Community Health Reporting Fellowship from the International Center for Journalists, which supported the testing that I conducted for my initial investigation on soil lead. While ICFJ no longer accepts applications for this fellowship, the center has an extensive resource page outlining investigative grants and other resources for journalists tackling in-depth reporting projects domestically and internationally.

The Harold W. McGraw Jr. Center for Business Journalism offers grants as well as editorial support for enterprise and investigative stories via its McGraw Fellowship for Business Journalism. This grant supported my second investigation on soil lead contamination in 2019 while I was a freelancer. This allowed me to do on-the-ground reporting and conduct research in libraries across the state for my "Ghosts of Polluters Past" series. McGraw applicants are not required to be business journalists. The fellowship welcomes generalists, and stories often cover a wide array of topics, such as health care, education, and the environment.

The Pulitzer Center, a nonprofit organization that supports independent global journalism, offers resources including a new yearlong fellowship for enterprise storytelling with innovative audience engagement approaches.

The Pulitzer Center's data journalism grant supports journalists with innovative data-driven projects that spotlight underreported issues. The grant pays for reporting expenses and has a rolling deadline.

Tackling lead contamination as an enterprise or investigative story takes time and resources.



Reporter Yvette Cabrera collected more than 1,600 soil samples around Santa Ana, California, analyzing each one for the presence of lead. The findings showed that a few neighborhoods were most affected by lead contamination. (Graphic: Clayton Aldern / Grist)

Step-by-step data analysis and visualization

This section, written by Grist's Clayton Aldern, offers detailed help for wrangling lead contamination data once you have it.

Data Cleaning and Geocoding

Let's go through how you might convert a list of addresses, each associated with a soil lead concentration from your samples, into latitude and longitude coordinates for use in GIS software like QGIS. This process is known as geocoding. We'll explore both an online tool method and a coding approach using Python.

Method 1: Using an Online Geocoding Service

Online geocoding services provide an easy and intuitive way to convert addresses to geographic coordinates. Services like the Google Maps Geocoding API, MapQuest, or OpenStreetMap's Nominatim are popular choices. Here, we'll discuss a generic process that applies to most online geocoding tools:

1. **Prepare Your Data:** Ensure your data is in a clean, structured format. A simple spreadsheet with columns for the address and soil lead concentration works well. Make sure each address is complete and correctly formatted to increase the accuracy of the geocoding process.
2. **Select a Geocoding Service:** Choose an online geocoding service that meets your needs. Considerations include cost, rate limits, accuracy, and ease of use. OpenStreetMap's Nominatim is a free option, while services like the Google Maps Geocoding API may require an API key—but offer a higher request quota and potentially more accurate results.
3. **Geocode Your Addresses:** This step varies by service. Generally, you'll either upload your spreadsheet or enter addresses manually, and the service will return the latitude and longitude for each address. For batch processing, some services allow you to upload a file, while others offer an API to automate the process programmatically.
4. **Export Your Data:** Once your addresses are geocoded, export the results back into a CSV file or other formats supported by the service. This file should now include columns for latitude and longitude alongside your original address and soil lead concentration data.

Method 2: Geocoding with Python

For those who prefer a more automated and customizable approach, Python provides libraries such as `geopy` that can interface with various geocoding services. Here's a basic outline of how you might use Python for geocoding.

Prerequisites:

- Install Python and pip (Python's package installer).
- Install the `geopy` library by running `pip install geopy` in your command line or terminal.

Step-by-Step Script:

This script assumes you have a CSV file named `soil_samples.csv` with at least two columns: `Address` and `LeadConcentration`, where:

- `Address` contains the full addresses of the soil sample locations.
- `LeadConcentration` contains the measured lead concentrations at those addresses.

The script will produce a new CSV file named `geocoded_soil_samples.csv`, adding two new columns: `Latitude` and `Longitude`.

Install Required Package

First, make sure you have `geopy` installed. You can install it using pip:

~~~
```sh
pip install geopy
```
~~~

Python Script

```
Python
import csv
from geopy.geocoders import Nominatim
from geopy.extra.rate_limiter import RateLimiter

# Initialize geolocator with a user-agent name (replace 'your_app_
name' with something unique)
geolocator = Nominatim(user_agent="your_app_name")

# Use RateLimiter to avoid hitting service limits
geocode_with_rate_limit = RateLimiter(geolocator.geocode, min_de-
lay_seconds=1)

def geocode_address(address):
    """Attempt to geocode an address and return latitude and lon-
gitude."""
```



```
    try:
        location = geocode_with_rate_limit(address)
        return (location.latitude, location.longitude) if location
else (None, None)
    except Exception as e:
        print(f"Error geocoding {address}: {e}")
        return (None, None)

def process_addresses(input_file, output_file):
    """Read addresses from input_file, geocode them, and write to
output_file."""
    with open(input_file, mode='r', encoding='utf-8') as infile,
open(output_file, mode='w', newline='', encoding='utf-8') as outfile:
        reader = csv.DictReader(infile)
        fieldnames = reader.fieldnames + ['Latitude', 'Longitude']
# Add new fields for lat/lon
        writer = csv.DictWriter(outfile, fieldnames=fieldnames)

        writer.writeheader()

        for row in reader:
            address = row['Address']
            lat, lon = geocode_address(address)
            row.update({'Latitude': lat, 'Longitude': lon})
            writer.writerow(row)

# Paths to your CSV files
input_csv = 'soil_samples.csv'
output_csv = 'geocoded_soil_samples.csv'

process_addresses(input_csv, output_csv)

print("Geocoding complete. Check the output CSV file for results.")
```

How to Use the Script

1. Replace `"your_app_name"` with a unique user-agent name for your application in the `Nominatim` initializer. This is required to identify your requests to the service.
2. Ensure your input CSV file is named `soil_samples.csv` and is located in the same directory as this script. Alternatively, modify `input_csv` to the path of your actual input file.
3. Run the script. The geocoded results will be saved in `geocoded_soil_samples.csv` in the same directory.

This script provides a basic but functional example of how to geocode addresses into latitude and longitude for further GIS analysis. Remember, when using online geocoding services, be mindful of their terms of service, especially regarding request limits and commercial use.

Data Analysis and Modeling

Next, you might want to compare soil-lead concentrations with other geospatial datasets to which you have access. For example, let's say you have a zip-code-level dataset of blood-lead levels in children. It might be beneficial to understand if there's a statistical relationship between your soil samples and those blood levels. Once you have geocoded your soil-sample locations, you can analyze the data to uncover trends and relationships. One effective way to do so is through linear regression.

Quick background on linear regression: Linear regression is a statistical method used to model the relationship between a dependent variable (y) and one or more independent variables (X). In its simplest form, it models the relationship between two variables by fitting a linear equation to observed data. The equation of a straight line (y = mx + b) represents this relationship, where:

- y is the dependent variable (what you're trying to predict),
- m is the slope of the line (how much y changes for a unit change in x),
- x is the independent variable (what you're using to make predictions),
- b is the y-intercept of the line (the value of y when x is 0).

The goal of linear regression is to find the best-fitting straight line through your data points that minimizes the differences between the observed values and the values predicted by the linear model.

Applying Linear Regression to Your Data

First, ensure your dataset is structured with your variables of interest. In this case, you'll need:

- The soil lead concentrations from your geocoded samples (independent variable).
- The blood lead levels by zip code (dependent variable).

Your analysis will be more robust if you can match the soil lead concentrations to the corresponding blood lead levels by zip code. This might involve averaging soil lead concentrations within each zip code or directly correlating individual samples to blood lead levels if your data allows. You may also be able to extract zip codes from your initial dataset of addresses.

Next, perform a linear regression analysis. You can use software like Excel, SPSS, R, or Python for linear regression analysis. Here, we'll outline how to do this using Python, assuming you have structured your dataset into a CSV file with columns for zip code, average soil lead concentration, and average blood lead level.

Python Example Using `statsmodels`

First, ensure you have the necessary Python package by installing `statsmodels`:

````
```sh
pip install statsmodels
```
````

Next, use the following Python script to load your data and perform a linear regression analysis:

```
Python
import pandas as pd
import statsmodels.api as sm

# Load your dataset
data = pd.read_csv('your_dataset.csv')

# Add a constant to the independent variable
X = sm.add_constant(data['SoilLeadConcentration'])  # Inde-
pendent variable
y = data['BloodLeadLevel']  # Dependent variable

# Fit the linear regression model
model = sm.OLS(y, X).fit()

# Print out the statistics
print(model.summary())

# You can also predict y values given new x values
# predictions = model.predict(X)  # where X includes new
values
```

Replace `'your_dataset.csv'`, `'SoilLeadConcentration'`, and `'BloodLeadLevel'` with the actual paths and column names in your dataset.

This script loads your dataset, performs a linear regression analysis to explore the relationship between soil-lead concentrations and blood-lead levels, and outputs a summary of the model's statistics. The summary provides potential useful insights, including the slope and intercept of the regression line, the coefficient of determination R^2, and p-values for hypothesis testing the relationships.

Interpreting Your Results

- Slope (m): If positive, an increase in soil-lead concentration is associated with an increase in blood-lead levels. The magnitude tells you the expected change in blood lead levels for a one-unit increase in soil lead concentration.
- Intercept (b): The expected blood lead level when soil-lead concentration is zero.
- R^2: Represents how well the independent variable explains the variation in the dependent variable. A higher R^2 indicates a better fit of your model to the data.
- P-values: Help determine the statistical significance of your findings. A p-value below a certain threshold (e.g. 0.05) suggests that the relationship observed is unlikely to be due to chance.

GIS Software and Spatial Interpolation

Next, you may seek to visualize your samples on a map. Importantly, you might want to interpolate soil-lead concentrations between the points you've measured, since you may not have an estimate for every spatial location in a given area. In order to do so, you can leverage a technique called Inverse Distance Weighting (IDW).

Quick background on IDW: IDW is a spatial interpolation method used to predict unknown values for any geographic point, based on the values of nearby points. The fundamental premise of IDW is that each measured point has a local influence that diminishes with distance. Mathematically, the influence of a point on the predicted value is inversely proportional to some power of the distance from the point to the location of the prediction.

The choice of power greatly affects the interpolation result. A higher power value gives more emphasis to the nearest points, making the interpolated surface more local and possibly more rugged. A lower power results in a smoother surface.

Step-by-Step Guide in QGIS 3.3

This guide assumes you're using the free, open-source tool QGIS (version 3.3 or higher). After opening QGIS, your first task is to load the dataset containing your soil lead concentrations and their geographical coordinates. If your data is in a CSV file, ensure it includes columns for latitude, longitude, and lead concentration.

- Navigate through "Layer" > "Add Layer" > "Add Delimited Text Layer."
- Browse to find your CSV file, select it, and make sure QGIS correctly identifies the latitude and longitude columns. You should see your points on the map reflecting the locations of soil sampling.

Next, access the IDW tool:

- Go to "Raster" > "Interpolation" to open the interpolation dialog.
- Here, you'll choose your layer (the CSV file you just loaded) as the 'Input vector layer'. Then, for the 'Interpolation attribute', select the column that contains your lead concentration values.

Set up IDW parameters next. In the interpolation dialog:

- Select "Inverse Distance to a Power" as the interpolation method.
- The "Power" parameter affects how distance influences the weighting of surrounding points. Experimenting with different values can help you understand its impact on the results. Starting with a power of 2 is common practice.
- Under "Output settings", define the extent of the area you want to interpolate across and set the resolution. The resolution will determine the size of the grid cells in your output raster. Smaller cells create a more detailed map but increase processing time and file size.

Execute the interpolation:

- Click on the "OK" or "Run" button to start the interpolation process. QGIS will then generate a raster layer representing your interpolated soil lead concentrations.
- Once the process completes, the new raster layer will automatically be added to your map. This layer visually represents the estimated lead concentrations across your area of interest, filling in the gaps between your sampled points.

Finally, fine-tune and visualize:

- To improve the visual interpretation of your results, adjust the layer's symbology. Right-click on the raster layer, select "Properties," and then "Symbology." Here, you can choose a color ramp that effectively highlights areas of concern.
- Use the "Identify Features" tool to click on various parts of your interpolated map, reading the estimated lead concentrations. This helps validate the model against known values and understand the distribution across unsampled areas.

Data Visualization and Getting It All Online

Next, you'll want to get your map on the internet to share with others. First, we'll export your interpolated raster data as a GeoTIFF file from QGIS.

After completing your spatial interpolation in QGIS (e.g., using Inverse Distance Weighting as discussed previously), ensure your interpolated raster layer is ready for export:

- Make any necessary visual or data adjustments to your raster layer.
- Ensure the layer is selected in the Layers Panel.

Export as a GeoTIFF:

1. **Open the Export Menu:**
   a. With your raster layer selected, right-click on the layer in the Layers Panel.
   b. Navigate to “Export” > “Save As...”. This opens the “Save Raster Layer As” dialog.
2. **Configure Export Settings:**
   a. Format: Select `GTiff/GeoTIFF` as the output format.
   b. File Name: Click on the “Browse” button to choose where to save your GeoTIFF file and what to name it.
   c. CRS (Coordinate Reference System): Ensure the CRS is set correctly for your dataset. You can use the same CRS as your project or choose a specific one that suits your requirements.
   d. Resolution: You can specify the output resolution. The default option typically uses the raster layer’s original resolution, but you can adjust this if needed for your specific application.
   e. Extent: Define the geographic extent of the output file. You can manually enter the coordinates, use the current extent of the map canvas, or select the extent of another layer.
   f. Advanced Options: There are additional settings that you can leave at their default values for most purposes, such as compression and nodata value.
3. Export the File:
   a. After configuring the settings, click on the “Save” button to export your raster layer as a GeoTIFF file. QGIS will process the export based on your specified options.

Additional Tips:

- **Review the Exported GeoTIFF:** Once the export process is complete, it’s a good idea to open the new GeoTIFF file in QGIS to ensure it exported correctly and matches your expectations.
- **GeoTIFF for Web Display:** As mentioned previously, if you plan to display this GeoTIFF online using tools like Mapbox GL JS, you may need to convert it to a more web-friendly format like MBTiles. The conversion process can be done using GDAL utilities or within QGIS through plugins that support this conversion. More on that in the next section!

By exporting your interpolated raster data as a GeoTIFF from QGIS, you prepare your dataset for a variety of uses, including detailed analysis, sharing with colleagues, or displaying online to a broader audience. For this walkthrough, we’ll use Mapbox GL JS, a powerful JavaScript library that allows for the creation of dynamic, interactive maps on web pages. We’ll assume you have your interpolated data in a GeoTIFF format from the previous steps, which we’ll first need to convert to a format suitable for web display, and then we’ll add it to a Mapbox map.

Your interpolated raster data is likely in a GeoTIFF format (as we created in the previous step). For web use, it’s often more efficient to use a format like MBTiles or GeoJSON, depending on your data’s complexity and type. Tools like `gdal_translate` (part of the GDAL library) can convert GeoTIFF files to MBTiles. For vector data, `ogr2ogr` (also from GDAL) can convert to GeoJSON:

````
```sh
gdal_translate -of MBTiles your_data.tif your_data.mb-tiles
```
````

This command converts a GeoTIFF file (`your_data.tif`) into an MBTiles file (`your_data.mbtiles`), which is more suitable for web mapping applications.

Before using your data in Mapbox GL JS, upload the MBTiles file to Mapbox Studio to create a tileset. Once uploaded, Mapbox will host this tileset, making it accessible via your Mapbox account for use in your maps.

Set Up Your Web Page

In a new HTML file, include the Mapbox GL JS and CSS files by adding the following lines in the `<head>` section:

````
```html
<link href='https://api.mapbox.com/mapbox-gl-js/v2.3.1/mapbox-gl.css' rel='stylesheet' />
<script src='https://api.mapbox.com/mapbox-gl-js/v2.3.1/mapbox-gl.js'></script>
```
````

Next, add a map container. In your HTML’s body, add a `div` element to serve as the container for your map:

````
```html
<div id='map' style='width: 100%; height: 400px;'></div>
```
````

Finally, initialize the map: You'll need a Mapbox access token, which you can obtain from your Mapbox account. Once you have one, add a script to initialize your map, set your access token, and add your interpolated data as a layer.

```
     ```html
     <script>
       mapboxgl.accessToken = 'YOUR_MAPBOX_ACCESS_TOKEN';
       const map = new mapboxgl.Map({
         container: 'map',
         style: 'mapbox://styles/mapbox/light-v10',
         zoom: 9,
         center: [-98.5795, 39.8283] // Example center coor-
dinates
       });

       map.on('load', () => {
         map.addSource('yourData', {
           type: 'raster',
           url: 'mapbox://yourusername.yourdataset', // Your
Mapbox tileset URL
           tileSize: 256
         });

         map.addLayer({
           id: 'yourData-layer',
           type: 'raster',
           source: 'yourData',
           paint: {}
         });
       });
     </script>
     ```
```

Replace `'YOUR_MAPBOX_ACCESS_TOKEN'` with your actual Mapbox access token and adjust the `url` in `map.addSource` to point to your uploaded dataset.

Customize and Publish Your Map

- **Customize:** You can adjust the `zoom` and `center` properties in the map initialization script to focus on the specific area covered by your data. The `paint` property of `map.addLayer` can be customized to change the appearance of your raster data on the map.
- **Publish:** Once your web page is set up, you can host it on any web server or platforms like GitHub Pages. Your interactive map will be accessible to anyone with the link.

Displaying your interpolated data online using Mapbox GL JS allows you to share your findings in an interactive, engaging format. By converting your data to a web-friendly format, uploading it to Mapbox Studio, and embedding the map on a web page, you make your geographic data analyses accessible to a broad audience, potentially enhancing the impact of your work.

Questions? Email caldern@grist.org.

Parting thoughts about covering lead

Yvette here: If you haven't already been delving into lead contamination, the contents of this guide might feel a little overwhelming. And a lot depressing.

But whether you're a reporter or a community member, you can make a difference. You don't need to do it all. One step at a time can lead you in a powerful direction.

I keep a quote on my desk from John Steinbeck that says: "On what point can I stand to see the world — or more important, to make the world see itself." It's a question I ask myself, because too often we fail to see what's right in front of us.

Helping people see and address the lead contamination that is, in fact, right in front of us will improve lives for generations to come.

Questions? Get in touch with me at getthedirtonlead@gmail.com.