The University of Chicago

Funding the Superfund: An Evaluation of the Superfund Amendments and Reauthorization Act Taxes' Impact on National Priority List Site Remediation Results

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Public Policy Studies
&
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Glossary

ATMI - Alternative minimum taxable income

CAGs - Community Advisory Groups

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act

EPA - Environmental Protection Agency

NPL - National Priorities List

Proposed NPL sites - Superfund sites awaiting NPL approval

Final NPL sites - NPL sites awaiting remediation or in the early stages of remediation

Deleted NPL sites - NPL sites fully remediated and therefore no longer on the NPL

HRS - Hazardous Ranking System

HSRTF - Hazardous Substance Response Trust Fund

PRPs - Potentially responsible polluters

SARA - Superfund Amendments and Reauthorization Act

TAGs - Technical Assistance Grants

CAGs - Community Advisory Groups

Abstract

As one of the most notoriously expensive and complicated agency-led programs in the country, the Superfund has stirred a contentious funding debate since its inception in 1980. While the excise taxes established by the Superfund Amendments and Reauthorization Act (SARA) in 1986 raised substantial revenues for the Hazardous Substance Response Trust Fund, allowing the EPA to fund removal, remediation, and enforcement actions at Superfund sites, they expired in 1995 resulting in a significant decline in the program's financial resources. Although researchers, EPA officials, and policymakers have recognized that this funding issue must be resolved, no consensus has been reached on the efficacy of the SARA taxes, causing attempts of reinstatement to fail again and again. Existing scholarship offers little to no insight into the connection between these taxes and the Superfund's on-the-ground remediation results further impeding policymakers from making informed decisions regarding the program's revenue collecting mechanisms.

My thesis seeks to fill this gap in research by evaluating how the SARA taxes impacted remediation outcomes of NPL final and deleted sites in EPA Region 5. To assess the influence the taxes had on this region's remediation decisions, I analyze how site-specific attributes change at deleted NPL sites across the tax expiration threshold. I also employ a comparative spatial study of host communities' demographics surrounding deleted NPL sites during and after the taxes. This mixed-methods approach enables me to identify if certain features of a site influenced its likelihood for cleanup during the presence or absence of the SARA taxes.

My findings indicate that Region 5 remediation decisions post-SARA were potentially driven by cost considerations resulting in the favoring of less complicated and costly sites as well as sites with present and able potentially responsible parties (PRPs). While these findings are Region 5 specific, they reveal a possible concerning trend in the Superfund's implementation of the remediation program. That being said, I call for more conclusive and nationwide research to be conducted for the link between the SARA taxes and remediation outcomes to be fully understood. This information can help guide policymakers to establish Superfund measures that enable it to meet its growing funding needs.

Introduction

After a boom in manufacturing in the nineteenth century, but before waste disposal regulation, an influx of toxic byproducts were dumped into landfills, lakes, and streams, or held in metal drums which were often buried, creating waste areas posing significant harm to human and environmental health (Schons 2011). As a result, in the late 1970s, hazardous waste sites were discovered across the United States, sparking a national demand for federal remediation action as adverse health effects such as chemical burns, miscarriages, birth defects, and cancers became directly tied to uncontrolled carcinogens and other toxic contaminants (McNeil 1978).

Public outrage following notorious hazardous waste sites such as Love Canal in New York, Valley of the Drums in Kentucky, and Times Beach Missouri, prompted lawmakers to enact the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980 (Nakamura and Church 2003, 51). Under the law, the Superfund Program was created, enabling the Environmental Protection Agency (EPA) to address contaminated sites such as abandoned industrial waste sites, chemical plants, landfills, mines, lagoons, and so on by transferring cleanup costs to potentially responsible parties (PRPs) or using revenue collected by the program's trust fund to remediate the country's most polluted sites, recorded on the National Priorities List (NPL) (Probst 2017, 1; Schons 2011). Each of the EPA's ten Regional offices, headed by one main manager per Region, were made responsible for implementing the Superfund Program within their designated states and territories (EPA 2020; Probst 2017, 1).

Trust fund revenues proved essential for addressing the approximately 30 percent of "orphan" NPL sites where PRPs were unidentifiable or unable to pay for their share of cleanup costs (Schmidt 2003, A165; Schons 2011). To solidify a steady source of trust fund revenues, the Superfund Amendments and Reauthorization Act (SARA) introduced new excise taxes on crude oil and petroleum, other waste-producing products and chemicals, and an environmental tax on various corporations in 1986 (GAO 2003). These taxes generated 68% of the revenues for the trust fund, enabling the EPA to make remediation progress on these orphan NPL sites (GAO 2003). Yet, under a Republican-controlled Congress in 1995, no consensus on reauthorizing the SARA taxes could be reached and they expired as a result (Schmidt 2003, A164). In the following years, the trust fund dwindled, shrinking from $2 billion in the fiscal year 1995 to $370 million in the fiscal year 2002 as appropriations were alternatively sourced from the government's general fund (GAO 2003). Thus, the Superfund funding burden was shifted from

the producers and users of hazardous waste to general taxpayers. Meanwhile, the number of NPL sites needing attention grew and Superfund remediation progress slowed (Probst 2017, xi).

Since 1995, there have been numerous attempts to reestablish the SARA taxes, most notably by the Clinton administration, yet industry opposition and uncertainty regarding their efficacy have hindered Congressional approval (Schmidt 2003, A164-A165; McCarthy 2003). Experts, lawmakers, and stakeholders are split in their opinions of the taxes; some claim the taxes can help solve the program's funding shortcomings, while others believe they are unfair, do not incentivize better waste management practices, and can be derived from elsewhere (LA Times 2002; Schmidt 2003, A165). Despite these concerns, the impacts of the SARA taxes on remediation decisions and actions remain unknown as reports have mainly focused on the taxes' contribution to Superfund trust fund appropriations, paying limited attention to site cleanups (GAO 2003, 2008; Probst et al. 2010). This has left the EPA more or less in dark about the relationship between the Superfund's funding and its intended results. My research seeks to fill this gap in existing scholarship by investigating how the expiration of the SARA taxes in 1995 affected remediation outcomes at NPL Superfund sites. Specifically, my study seeks to explore two core issues: how NPL site-specific characteristics changed as a result of the taxes' expiration and whether there was a shift in the types of NPL host communities that were prioritized for cleanup post-SARA.

In examining the impact of the SARA taxes on remediation decisions and results, my thesis specifically focuses on EPA Region 5, which includes Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin (EPA 2020). Narrowing my focus to a regional area accounts for the reality that Superfund site decisions, while informed by national standards and procedures, are carried out by regional managers who have distinct approaches (Nakamura and

Church 2003, 56; Probst et al. 2001). I will be researching the years 1991-2002, analyzing how Region 5 sites fully remediated from 1991 to 1996 compare to those fully remediated from 1997 to 2002. Although 1989 was the first year all SARA taxes were in effect, there is more substantial data on the tax revenues from 1991, allowing me to directly compare remediation outcomes with fund appropriations (GAO 2003; McCarthy 2003). The year 1997 marked the beginning of a steady decline in trust fund revenues once a large portion of the remaining collections from cost recoveries and interest payments from the taxes were utilized (Dougherty and Gilson 1994; GAO 2003). These years of focus allow for the window directly before the SARA taxes expired and directly after to be studied in parallel. Through this framework, I assess if certain sites and communities were prioritized for remediation across the SARA expiration threshold.

To employ my comparative analysis, I use a mixed-methods approach, first collecting detailed data from the EPA's "Superfund Archived Data and Reports" on NPL Superfund site characteristics such as category, total actions led by the EPA trust fund, PRPs, the state, federal enforcement or other entities, stakeholder remedial design and action leads, and the presence of community groups at sites. Analyzing how these site-specifics change after the SARA enables me to identify what influence the taxes had on remediation decisions. For the second part of my analysis, I use geographic information systems to map Region 5 EPA NPL site point data acquired through NASA's Socioeconomic Data and Applications Center (SEDAC) and U.S. Census data acquired through IPUMS National Historical GIS (NHGIS). This enables me to study the socioeconomic and demographic makeup of the NPL host communities in close proximity to sites. This spatial approach, which utilizes thematic mapping and buffer analysis, provides greater insight to whether the income, race, or ethnicity of a community played a role in

remediation decisions during the SARA taxes. Together, these two approaches allow me to assess the impact of the SARA taxes on site-specific and community-based Region 5 NPL remediation decisions and outcomes.

This research will offer insight into the highly debated, yet little studied efficacy of the SARA taxes. Assessing how these taxes impacted Superfund remediation outcomes in EPA Region 5 can help inform future policy decisions on how to best fund the program. Where should revenues for the trust fund be drawn? Should taxpayers contribute to the fund or should producers and heavy users of hazardous waste pay their share? Without a more conclusive understanding of the SARA taxes' influence on site outcomes, policymakers cannot determine the most effective way to replenish the trust fund.

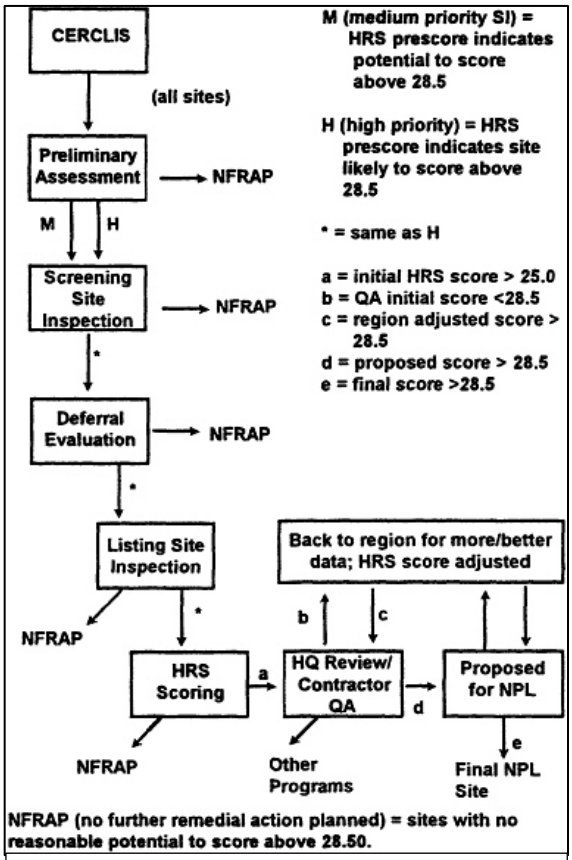
My findings indicate that the absence of the SARA taxes potentially led Region 5 to prioritize NPL sites that were relatively cheaper and less complicated than those remediated during the taxes. This can be seen in shifts in site categories and action leads of remedial design and action at NPL deleted sites indicating that without the taxes, Region 5's remediation decisions were likely driven by cost considerations. This has implications for the implementation of the Superfund as financial barriers can impede the program from accomplishing its mission to clean up the *most* dangerous hazardous waste sites first. Based on my findings, the SARA taxes appeared to help remedy this issue to some extent. Aside from the site-specific characteristics, the SARA taxes had no significant impact on what host communities' sites were prioritized for remediation as revealed by my study of the average percent white, nonwhite, and Hispanic as well as average per capita income of final and deleted NPL host communities.

Historical Background

The Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA, was established on December 1, 1980 under President Jimmy Carter granting the EPA the power to remediate contaminated sites across the country (Probst 2017, 1). Under CERCLA, the Hazardous Ranking System (HRS) was implemented, assigning a numerical "score" to investigated uncontrolled sites to determine their placement on the National Priorities List (NPL) (EPA 2015). Sites with an HRS of 28.5 or higher earn NPL status making them some of the most hazardous, complicated, and costly Superfund sites in the country (Probst 2017). HRS scoring is a complex multistep process, thus, for the sake of simplicity, this system can be summarized in Figure 1 below. Once added to the NPL, sites are characterized as either "proposed," "final," or "deleted" (EPA 2015). Proposed sites include sites waiting to be finalized on the NPL where remediation actions are typically in the early stages (EPA 2015). Final NPL sites are those officially listed on the NPL, but still awaiting full remediation (EPA 2015). NPL sites designated as deleted have received all necessary remedial actions and are no longer considered an active Superfund site (EPA 2015). My research is mainly concerned with final and deleted NPL sites. A more in-depth depiction of the NPL remedial pipeline is shown in in Figure 2. I have included a map of the current 1,327 NPL sites that exist today as seen in the EPA's "Superfund National Priorities List (NPL) Where I Live Map" and accessed for interactive viewing here so the scope and distribution of these proposed, final, and deleted NPL Superfund sites can be visualized and better understood (Figure 3) (EPA 2021).[1]

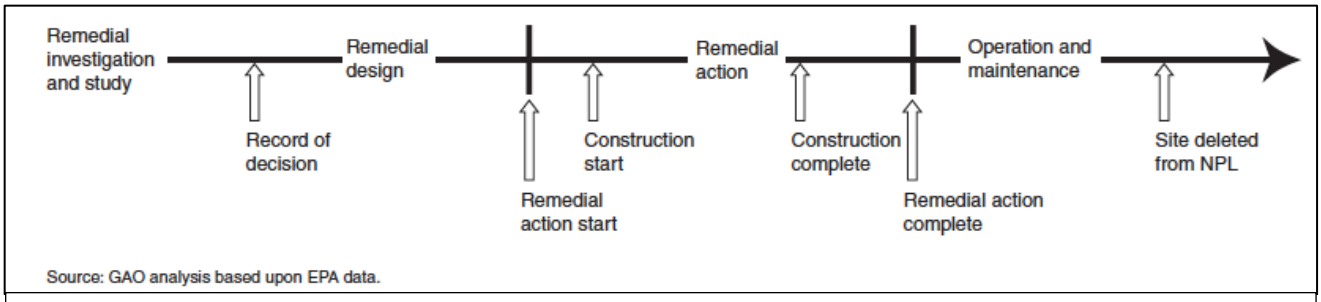
[1] U.S. Environmental Protection Agency. "Superfund National Priorities List (NPL) Where I Live Map." ArcGIS Web App Viewer. U.S. Environmental Protection Agency. Accessed April 5, 2021. https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=33cebcdfdd1b4c3a8b51d416956c41f1.

Figure 1: Hazardous Ranking System Scoring Process



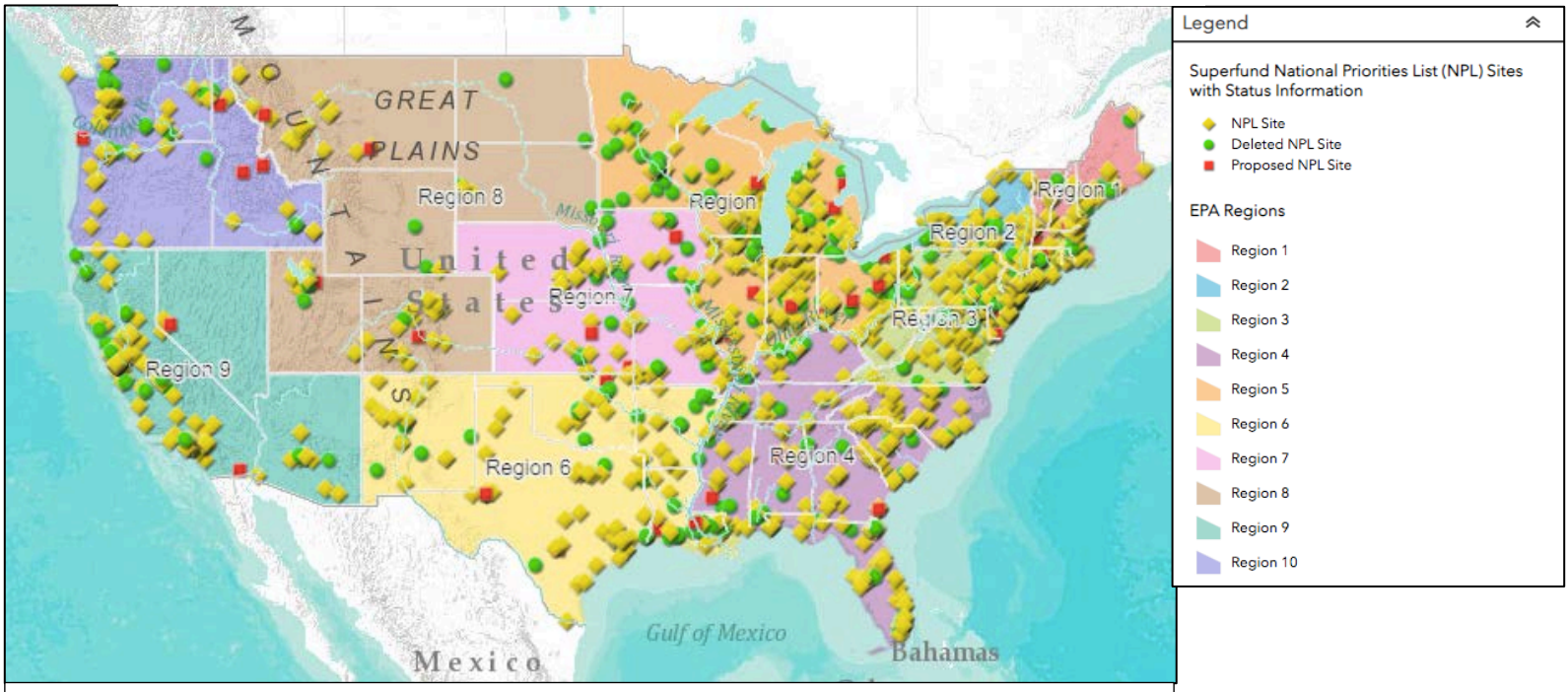
Source: National Research Council. *Ranking hazardous-waste sites for remedial action*. National Academies Press, 1994.

Figure 2: Stages of the Remedial Process at NPL Sites



Source: U.S. Government Accountability Office. "SUPERFUND PROGRAM: Current Status and Future Fiscal Challenges." Report to the Chairman, Subcommittee on Oversight of Government Management, the Federal Workforce, and the District of Columbia, Committee on Governmental Affairs, U.S. Senate. U.S. Government Accountability Office, July 2003. https://www.gao.gov/assets/240/239184.pdf.

Figure 3: EPA Superfund National Priorities List (NPL) Where I Live Map



U.S. Environmental Protection Agency. "Superfund National Priorities List (NPL) Where I Live Map." ArcGIS Web App Viewer. U.S. Environmental Protection Agency. Accessed April 5, 2021. https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=33cebcdfdd1b4c3a8b51d416956c41f1.

In order to fund the majority of Superfund cleanups, CERCLA created a "retroactive, strict, joint, and several liability scheme" requiring potentially responsible parties (PRPs) who had been or were currently involved with a hazardous site to front hefty remediation bills (Nakarmura and Church 2003, 53). CERCLA is "retroactive" as it can hold PRPs accountable for uncontrolled hazardous waste that had accumulated before the law was in place (Nakarmura and Church 2003, 53). "Strict" refers to the law's requirement that PRPs should be held liable even if they did not directly cause the mishandling of contaminants, while "joint and several" refers to the responsibility of any liable PRP to pay the total cost of the Superfund cleanup (Nakarmura and Church 2003, 53). Although these mechanisms were successful in collecting needed site cleanup funds, this liability strategy drew substantial criticism (Nakarmura and Church 2003, 53). Under the law, conglomerate PRP corporations often used their leverage to entangle smaller third-party "polluters" in a web of litigation transferring costs down the latter (Nakarmura and

Church, 53). These third-parties including current owners and operators, past owners and operators, arrangers of hazardous waste disposal, and transporters of this waste, can often face the brunt of site cleanup expenses due to lack of strong legal representation or corporate power (Cornell Law 2021; Nakarmura and Church, 53). Given that the implementation of CERCLA often led to these controversial results, scholarship on the Superfund Program mainly focuses on the issues with this litigation, paying limited attention to the second main feature of CERCLA: The Hazardous Substance Response Trust Fund (HSRTF).

The HSRTF allows the EPA to fund removal, remediation, and enforcement actions at NPL sites where PRPs cannot be identified or are unable to pay (Judy and Probst 2009, 213). The trust fund also provides revenues for the Superfund's operating costs, expenses, and emergency needs (Judy and Probst 2009, 213). A sufficient trust fund balance is key to the program's ability to assess hazardous sites, remediate these sites, and lead cleanups with no PRP (Judy and Probst 2009, 246). The fund originally collected revenues from excise taxes on crude oil and feedstock chemicals and general fund revenues, however, in 1986 new taxes were introduced under the Superfund Amendments and Reauthorization Act or SARA (Dougherty and Gilson 1994). SARA created new excise taxes on petroleum, feedstock chemicals, imported chemical substances, and a corporate environmental tax to raise revenues for the Superfund Trust Fund causing a substantial shift in CERCLA's funding mechanisms (Dougherty and Gilson 1994). Under SARA, petroleum was taxed 9.7 a barrel for domestic and imported products compared to the .79 cents a barrel originally set by CERCLA resulting in $2.635 billion in receipts over 5 years (Dougherty and Gilson 1994). The feedstock chemicals tax remained mostly unchanged since 1980, collecting receipts from 42 organic and inorganic chemicals (Dougherty and Gilson 1994). A tax on 72 imported chemical substances also remained more or

less unchanged (Dougherty and Gilson 1994). Lastly, SARA introduced a new environmental corporate income tax based on corporate alternative minimum taxable income (ATMI) on all corporations with ATMI exceeding $2 million (Dougherty and Gilson 1994).

Each tax contributed a different share of receipts to the trust fund. Tax receipts on petroleum alone multiplied the trust fund revenues by accounting for approximately 45% of its revenues compared to an original 15% contribution (Dougherty and Gilson 1994). The two chemical taxes, on the other hand, accounted for only a 20% share in revenue collection, down from 85% (Dougherty and Gilson 1994). Together, all the SARA tax amendments raised four times the amount of revenues for the trust fund than CERCLA's tax amounts making their enactment crucial to maintaining a sufficient trust fund balance (Dougherty and Gilson 1994). A comparison between the CERCLA and SARA tax revenues and amounts can be seen in Figures 4 and 5. Despite their primary role in raising revenues for Superfund remediation efforts, the taxes expired with SARA in 1995 (GAO 2003). As a result, revenues had to be collected from the general fund (Probst 2017, 1). In the subsequent years, the taxes failed to be reinstated and the trust fund dwindled, as shown in Figure 6, impacting Superfund's ability to clean up the growing number of sites requiring remediation action (GAO 2003).

Figure 4

COMPARISON OF INITIAL CERCLA AND SARA TAX REVENUES

Period: / Taxes	Initial CERCLA (1) 1981 to 1985 ($000)	% of Total	SARA (2) 1987 to 1991 ($000)	% of Total
Tax on Petroleum	225,000	15.0%	2,635,300	44.5%
Tax on Feedstock Chemicals	1,275,000	85.0%	1,208,000	20.4%
Tax on Imported Chemical Substances	NA	NA	*	*
Corporate Environmental Income Tax	NA	NA	1,853,000	31.3%
Adjustments**	NA	NA	220,917	3.7%
Total	1,500,000	100.0%	5,917,217	100.0%

* Included in the total for the tax on feedstock chemicals.
** Adjusted to account for 1992 income subject to the corporate environmental tax but not included in the five-year data.

Source: Industrial Economics Incorporated. "Economic Impacts of Superfund Taxes." Cambridge, Massachusetts, February 1994. https://www.epa.gov/sites/production/files/2018-02/documents/ee-0096_1-2_acc.pdf.

Figure 5

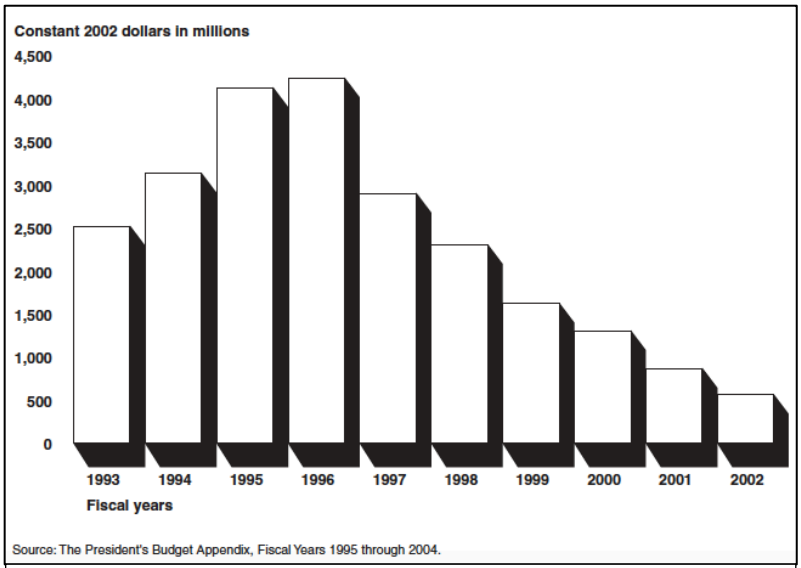
COMPARISON OF INITIAL CERCLA AND SARA TAX AMOUNTS

TAXES	CERCLA TAX AMOUNT	SARA TAX AMOUNT
Tax on Petroleum	0.79 cents per barrel imported and domestic	9.7 cents per barrel imported and domestic
Tax on Feedstock Chemicals	1) 2% of estimated wholesale price prevailing at that time OR 2) $4.87 per ton for organic chemicals $4.49 per ton for inorganic chemicals	SAME AS CERCLA
Tax on Imported Chemical Substances	NA	1) "Calculated by determining the number of tons of each taxable feedstock chemical used in the manufacture of one ton of the imported substance, or by determining the percentage of taxable metals in the substance." 2) "If the importer does not have sufficient information to determine these quantities, the tax is set at 5% of the appraised value of the imported chemical substance."

Corporate Environmental Income Tax	NA	0.12% of AMTI in excess of an $2 million AMTI

Dougherty, Charlotte P., and Elizabeth S. Gilson. "Economic Impacts of Superfund Taxes." *prepared by Industrial Economics Inc., for the US Environmental Protection Agency, February, Washington DC* (1994).

Figure 6: The Balance of the Superfund Trust Fund Available for Future Appropriations, Fiscal Years 1993-2002



U.S. Government Accountability Office. "SUPERFUND PROGRAM: Current Status and Future Fiscal Challenges." Report to the Chairman, Subcommittee on Oversight of Government Management, the Federal Workforce, and the District of Columbia, Committee on Governmental Affairs, U.S. Senate. U.S. Government Accountability Office, July 2003. https://www.gao.gov/assets/240/239184.pdf.

Efficacy and "Fairness" Considerations

Although the SARA taxes collected substantial revenues for the trust fund bringing its balance to almost $4 billion in 1995, economic efficiency and "fairness" considerations hindered their reinstatement (McCarthy 2003). The taxes were also met with strong industry opposition from corporate petroleum and chemical companies who argued that the taxes were too removed from the contaminants that ended up at Superfund sites (NYT 2009; Klott 1985; Dougherty and Gilson 1994; McNeil et al. 1998). Congress initially created the SARA taxes with intentions that they would raise revenues from the sale, production, and use of hazardous products and serve as economic controls for hazardous waste externalities (Mamlyuk 2010, 51; McNeil 1998). Yet, despite being founded on this "polluter pays principle," the taxes had no direct connection to the proportion of hazardous waste generated or how it was disposed (Dougherty and Gilson 1994).

Additionally, the taxes' heightening of petroleum and chemical prices were not substantial enough to impact the demand for these products (Dougherty and Gilson 1994). Yet, simply raising the taxes was predicted to hinder the steadiness and flow of revenue collection (Dougherty and Gilson 1994). This resulted in the SARA taxes ultimately providing "limited incentive to use fewer damaging chemicals…limited incentive to minimize waste generation, and no direct incentive to manage waste more responsibly" according to economic researchers (Dougherty and Gilson 1994). These implementation issues tainted confidence in the SARA taxes' efficiency leaving many to question their enactment.

Despite these shortcomings, the alternative solution (funding the Superfund through taxpayer money from the general fund revenues), also raised concern among researchers, lawmakers, EPA officials, and other stakeholders (McCarthy 2003). Those in favor of the SARA taxes have argued that shifting the Superfund funding burden to taxpayers has let corporate polluters more or less off the hook, while simultaneously allowing the trust fund to dwindle (Schmidt 2003, A165). Since the general fund has been the main source of revenue for the program following the taxes' expiration, the trust fund balance has been in decline (GAO 2003). Without the SARA taxes, taxpayer money used to fund other programs such as defense, homeland security, Medicare, Social Security, transportation, etc. must also be used to fund the costly Superfund (McCarthy 2003). Meanwhile, since 1995, remediation costs have increased as the number of "mega sites," sites with cleanup of $50 million or more, have grown (McCarthy 2003). These issues have brought some experts and lawmakers to call for the reinstatement of the SARA taxes to revamp the program (Schmidt 2003, A165). While the effect of the SARA taxes on on-the-ground remediation results has not been explored in previous scholarship, there is a

universal understanding that these funding limitations must be resolved (GAO 2003; Probst et al. 2001).

Literature Review

Ample scholarship has explored how agency funding for issue areas such as education, criminal justice, and healthcare to just name a few, connect to social-welfare results such as test scores, crime rates, and public health (Nash et al. 2017). Research on these topics has informed lawmakers' budgetary decisions by equipping them with tools to understand the impact funding will have on an agency's intended goals. However, the relationship between funding and outcomes has not been widely studied in the context of regulatory agencies like the EPA (Nash et al. 2017). Regulatory agencies are unique as their funding resources often depend on the role of regulated actors; thus, their budgets are not as directly connected to on-the-ground results (Nash et al. 2017). In existing literature, a theoretical framework for evaluating this link has yet to be formally established; even Congressional reports charged with assessing regulatory agency progress have failed to pair funding levels with outcomes (Nash et al. 2017). In a system where government agencies compete for general revenues, this unknown has serious implications as some programs may not yield better results with more funding. Costly programs such as the Superfund have historically been unable to assess how its budget affects the issues it sets out to resolve (Nash et al. 2017). Investigating the impact of the SARA taxes on Superfund remediation outcomes will shed light on the relatively unexplored relationship between regulatory agencies' fiscal resources, implementation, and outcomes.

Existing scholarship mainly discusses the SARA taxes in relation to the trust fund's fluctuating revenues and appropriations. Only a handful of comprehensive reports conducted by

research organizations, government offices, and consultancy firms, at the request of Congress, have evaluated the taxes' impact on the trust fund balance and program expenditures over time (CRS 2008; Dougherty and Gilson 1994; GAO 2003; McCarthy 2003). These reports offer limited analysis of the taxes themselves and are instead mainly concerned with determining the funds needed to make sufficient Superfund remediation progress. Yet, overall, there has been a consensus among this scholarship that the trust fund's balance and appropriations have steadily declined since 1997 due to the SARA taxes' expiration. Researchers have concluded that the absence of these taxes has further complicated the program's ability to meet compounding expenses, leading to a contentious debate over whether they should be reinstated (GAO 2003, McCarthy 2003).

Other relevant scholarship conducted by Katherine Probst, leading expert and author on Superfund, discuss Superfund's funding and remediation processes more generally without paying specific attention to the SARA taxes (Probst et al. 2001; Judy and Probst 2009; Probst et al. 2001). These reports set out to assess the Superfund program's progress over time through examining the impact of site-specific attributes on remediation results. Thus, while this research is somewhat tangential to my focus, it highlights the multifaceted factors that influence remediation prioritization and decision-making.

The SARA Taxes and the Trust Fund

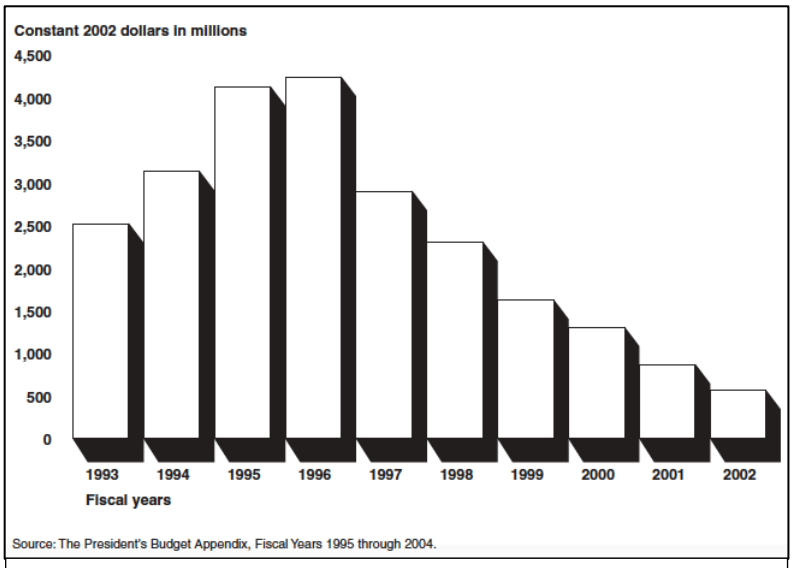
Reports assessing the Superfund program's future fiscal challenges and funding trends offer the most insight into the relationship between the SARA taxes and remediation outcomes. The Government Accountability Office (GAO) conducted one of the main reports on the SARA taxes and the trust fund balance in 2003 at the request of Congress (GAO 2003). GAO's research

assessed the Superfund's past progress to inform the program's future funding needs. The report highlighted how the trust fund balance and available appropriations declined after the SARA expiration. Using bar charts, GAO depicted this change in funding post-SARA and connected available appropriations with NPL cleanup status. As demonstrated in Figure 7, GAO found that the overall balance of the Superfund trust fund available for future appropriations significantly drops after 1996, decreasing from more than $2 billion in 1995 to under $370 million in 2002 (GAO 2003). Without the SARA taxes, GAO reported that the Superfund had to derive more and more of its revenues from the general fund, especially after 1999 as shown in Figure 8 (GAO 2003). Despite this decline in Superfund's available appropriations and simultaneous increase in general fund support, GAO reported that the EPA continued to add more sites to the NPL since 1993, while the program's overall expenditures stayed between $1.3 and $1.7 billion from 1993 to 2002 (GAO 2003). Additionally, as depicted in Figure 9, the number of NPL sites steadily grew since 1993 with 238 NPL sites added from 1993 to 2002 (GAO 2003). These findings, together, indicate that the Superfund has faced a serious funding dilemma since the expiration of SARA. This poses an especially precarious issue as GAO predicts the EPA will have to fund more NPL sites in the near future given the likeliness of increasing numbers of "unviable" potentially responsible parties (GAO 2003).

While this GAO report does not directly connect the SARA taxes' to on-the-ground remediation outcomes, it does provide insight into the general funding and NPL remediation pipeline trends the program experiences post-SARA. It specifically demonstrates that the Superfund's funding resources are inadequate for the program's increasing NPL site listings and remediation demands (GAO 2003). In this sense, the report emphasizes that the SARA taxes were crucial to keeping at pace with the remediation program (GAO 2003). Yet, the taxes' on-

the-ground impact on NPL site-specific results and host-community prioritization are not explored. This information is especially important to understanding the SARA taxes' implementation results and overall efficacy. While it is clear that the Superfund needs an additional funding resource besides general fund revenues, there is no consensus on what would constitute the most effective solution to this issue. My research seeks to fill this gap in scholarship through investigating the efficacy of the SARA taxes.

Figure 7: The Balance of the Superfund Trust Fund Available for Future Appropriations, Fiscal Years 1993-2002



U.S. Government Accountability Office. "SUPERFUND PROGRAM: Current Status and Future Fiscal Challenges." Report to the Chairman, Subcommittee on Oversight of Government Management, the Federal Workforce, and the District of Columbia, Committee on Governmental Affairs, U.S. Senate. U.S. Government Accountability Office, July 2003.

Figure 8: Total Appropriations to the Superfund Program, Fiscal Years 1993-2002

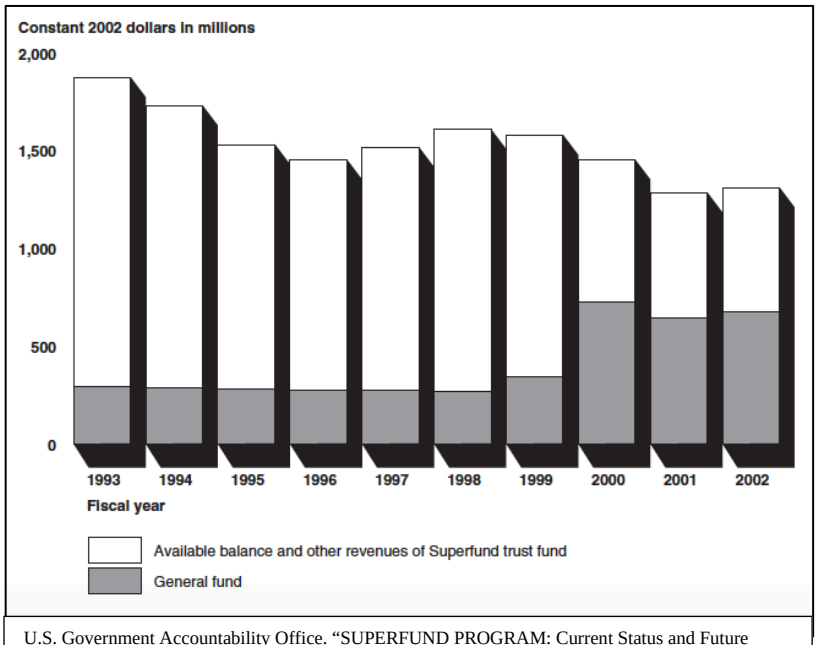


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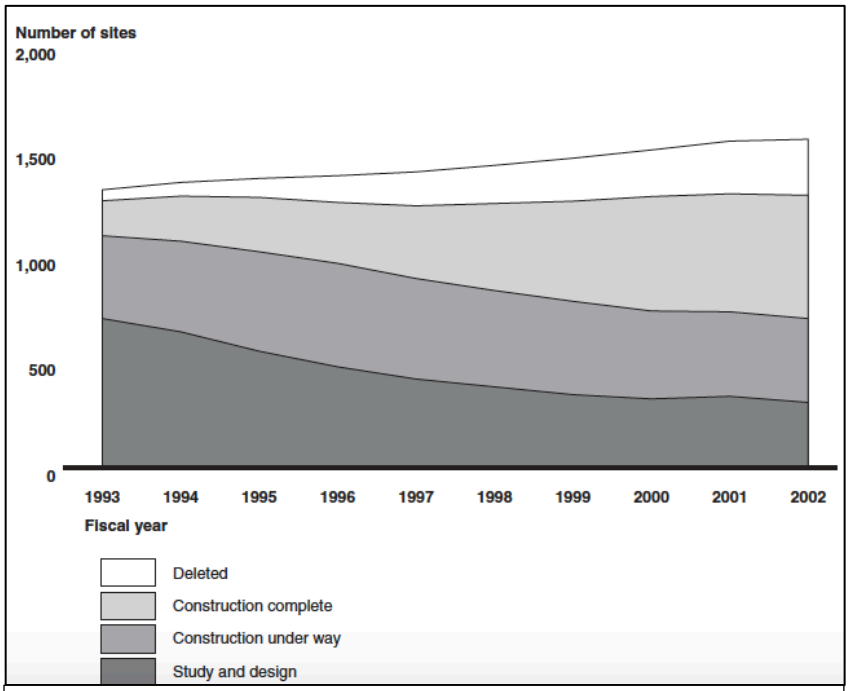
Figure 9: Cleanup Status of Proposed, Final, and Deleted NPL Sites



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The impact of NPL site characteristics and actions on remediation results

Reports other than the Government Accountability Office's stray from a discussion of the SARA taxes and instead focus on the relationship between Superfund funding and NPL sites in general (Daley 2007; Macey and Cannon 2007; Probst et al. 2001; Judy and Probst 2009; Probst et al. 2001). The impact of NPL site-specific characteristics, potentially responsible polluter involvement, and the presence of community groups have been studied in connection to remediation costs and outcomes.

Katherine Probst has deeply examined the ties between the Superfund remediation pipeline and the program's funding resources in multiple studies (Probst et al. 2001; Judy and Probst 2009; Probst et al. 2001). In two of her reports, "Funding the Superfund: what will it cost?" and "Superfund 2017," she analyzed how NPL site characteristics connected to the program's expenses (Probst et al. 2001; Probst 2017). In the 2001 study with Resources for the Future (RFF), for example, researchers created an estimation model to predict future program costs, directly tying a number of NPL factors to remediation price tags (Probst et al. 2001). In constructing their model, RFF collected site-specific data such as the number, type, and date of actions undertaken at a site, which party led each action, site size, contaminants of concern, operable unit numbers (OUs), and, finally, the total price of cleanup (Probst et al. 2001, 37). By assessing how these key variables impacted remediation costs, the researchers linked certain site characteristics to Superfund funding, and ultimately, remediation results (Probst et al. 2001, 37).

Specifically, both reports emphasized how a site's category can impact remediation decisions (Probst et al. 2001; Probst 2017). Different site categories including chemical manufacturing, oil refining, mining, wood preserving, coal gasification and other industrial, recycling, captive waste disposal, non-captive waste disposal, transportation, contaminated areas,

and miscellaneous can have varying strains on Superfund funds (Probst et al. 2001, 40; Probst 2017). Thus, slowed remediation progress in any given year can stem from more complicated and costly sites on the NPL (Probst et al. 2001). This research by Probst and others provides a useful perspective of site characteristics affecting Superfund demands, however, it does not examine the difference between the categories of final and deleted sites. Comparing the trends of fully remediated sites with those awaiting cleanup would offer more insight into how NPL sites are prioritized. How does a site's category impact its likelihood for remediation? This type of analysis would prove more useful for assessing whether the SARA taxes impacted the types of sites that were deleted from the NPL.

Besides site category, another major factor of the NPL remediation process that has been connected to Superfund funding is the proportion of site actions led by potentially responsible parties (PRPs). Since trust funds are used to remediate sites with no able or identifiable PRP, if the balance is low, NPL sites with PRPs may be favored for cleanup action. Probst and Judy have examined the distribution in action leads over time giving percentage breakdowns for fund-lead or PRP-lead actions at different points in the remedial pipeline (Judy and Probst 2009). Their scholarship analyzed these breakdowns for the years 1980-1986, 1987-1990, 1991-1999, and 2000-2008, but did not cover before and after the SARA tax expiration (Judy and Probst 2009). Despite this, information can be gained from comparing the report's 1987-1990 and 2000-2008 findings as this includes time frames both while the taxes were in effect and after their expiration. Probst and Judy find that there was 8% more fund-lead than PRP-lead remedial actions at NPL sites from 1987-1900 (Judy and Probst 2009). On the other hand, from 2000-2008, PRPs lead 28% more remedial actions at NPL sites (Judy and Probst 2009). This represents a 36% increase in PRP-lead remedial actions since the taxes had expired. While the

report does not discuss this shift, it is important to note that without SARA tax revenues, the EPA might have been less able to take on the high remedial action costs at NPL sites (Judy and Probst 2009). To determine if this was the case, my research specifically studies the change in remedial action leads directly before and after the SARA expiration.

Other research has focused on the influence community stakeholders have over remediation decisions at Superfund sites (Daley 2007; Macey and Cannon 2007). Multiple studies have examined the impact of Community Advisory Groups (CAGs) and Technical Assistance Grants (TAGs)—community groups organized and funded by the EPA—on remediation outcomes (Daley 2007; Macey and Cannon 2007). These studies indicate the presence of CAGs and TAGs improve a site's likelihood of receiving health-protective remediation outcomes (Daley 2007; Macey and Cannon 2007). Thus, this research proves that evaluating the presence of community groups at Superfund sites is worth assessing when researching the SARA taxes. If there is a substantial shift in community group presence across the tax expiration threshold this finding could have important implications for my study, because without the SARA taxes, CAGs may carry more influence over site remediation prioritization and likelihood. This would speak to the equity of the SARA taxes as a favoring of NPL sites with these CAGs could disadvantage communities that do not have the time, social capital, resources, or knowledge to come together to vouch for site updates and action.

Environmental justice concerns

When evaluating the efficacy of the SARA taxes, it is important to investigate if NPL host communities with certain socioeconomic or racial and ethnic compositions were favored over others in order to assess the taxes' environmental justice implications. In my research, I

utilize Robert Bullard's, definition of environmental justice as he is often considered the 'father of environmental justice.' He states, "Environmental justice embraces the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations" (Bullard 1996). As discovered in the United Church of Christ Commission for Racial Justice's (UCC) study conducted in 1986, this concept of environmental justice was being significantly violated by the disproportionate siting of hazardous waste sites in low-income communities and communities of color (UCC 1987). Through examining the relationship between a communities' racial, ethnic, and socioeconomic characteristics and the location of hazardous waste sites across the United States, UCC found that race, above all, was the most significant indicator of where a commercial hazardous waste site was located (UCC 1987). Additionally, communities with "the highest composition of racial and ethnic residents" had the most commercial hazardous waste facilities (UCC 1987). Here, a commercial facility refers to "any facility (public or private) which accepts hazardous wastes from a third party for a fee or other remuneration" (UCC 1987).

Socio-economic status including income levels and home values were found to be lower in communities with a commercial hazardous waste site, but not as influential as race disparities (UCC 1987). Uncontrolled toxic waste sites defined in the study as "closed and abandoned sites on the EPA's list of sites which pose a present and potential threat to human health and the environment" were found to be disproportionately concentrated in communities with Black and Hispanic residents especially in urban areas (UCC 1987). UCC's study, the first nationwide report on the subject matter, illuminated the stark disparities among what types of communities face the brunt of hazardous waste exposure (UCC 1987). UCC's report not only paved the way for many similar studies to come, but also highlighted the importance of equitable

implementation of EPA's cleanup programs specifically calling for the prioritization of uncontrolled toxic waste sites in Black and Hispanic communities (UCC 1987). Thus, investigating how agency programs such as the EPA's Superfund, implements its remediation program under various conditions like the presence or absence of the SARA taxes can provide critical information to agency leaders and policymakers on the equity of particular funding mechanisms. While this study was conducted in 1987, this environmental justice issue is still pertinent today as many vulnerable communities continue to be plagued by uncontrolled contaminants from hazardous waste facilities (Burwell-Naney et al. 2013; Greenstone and Justin Gallagher 2008; Maranville et al. 2009).

Other more recent studies, often modeled off of UCC's research, have also found that those who are non-white and Hispanic are more likely to live near Superfund sites, while other community characteristics such as income, homeownership, and education levels are less determinant of proximity to hazardous waste (Burwell-Naney et al. 2013; Greenstone and Justin Gallagher 2008; Hird 1993; Maranville et al. 2009). Despite these findings, there has not been wide-ranging research exploring how a host community's composition impacts remediation progress at Superfund sites. Additionally, no study has analyzed this subject in relation to the SARA taxes impact on remediation decisions and outcomes. While a study by John Hird in 1993 set out to identify how factors including the level and severity of contamination, political influence, racial and economic characteristics of the region, and community involvement may expedite or slow remedial efforts from 1989-1993 (while the SARA taxes were in effect), there was no analysis of these factors after the taxes' expiration (Hird 1993). Yet, Hird's study does offer insight into what trends were taking place while the SARA taxes were implemented (Hird 1993).

If inequities exist among remedial attention at Superfund sites, this could exacerbate the already disproportionate exposure of minority communities to hazardous waste. Living in close proximity to a Superfund site can have life-altering health implications, especially for young children who face prenatal exposure (Persico et al. 2020). Consequences of residing near a site are best studied in infants as they have not experienced the larger range of confounding factors that contribute to an adult's health (Persico et al. 2020). Research has indicated that exposure at a prenatal state heightens incidences of infant mortality, low birth weight, congenital disorders, and fetal brain development disruption (Persico et al. 2020). A long-term study based on population-level data in Florida analyses how living near a Superfund site affected children over time in comparison to their siblings who were born after remediation efforts were in place (Persico et al. 2020). This research draws connections between human health and the benefits of Superfund cleanup, emphasizing that "remediation of sites substantially benefits children's cognitive development" (Persico et al. 2020). Studies such as this speak to the importance of equitable site remediation as neglected sites can have generational health consequences that live on through already disadvantaged families.

Currently, scholarship examining how the socioeconomic and racial composition of host communities influences a site's likelihood for cleanup is lacking. Research on this issue is especially important considering that regional managers have to prioritize certain sites over others when Superfund funds are low. Thus, investigating if fewer funds lead to an inequitable distribution of remediation action has significant implications not only for Superfund budgetary decisions but also for human and environmental health.

Summary

Through an examination of existing literature, it is evident that the impact of the SARA taxes on remediation decisions and results at NPL Superfund sites has yet to be explored. While studies have demonstrated that the taxes led to a substantial decline in available trust fund appropriations and an increase in general fund revenue collection, this research does not link these funding shifts to on-the-ground NPL remediation outcomes (GAO 2003; McCarthy 2003). This has resulted an inconclusive understanding of how Superfund's remediation program was directly affected by SARA's expiration. Additionally, analyzes investigating shifts in NPL site-specific characteristics such as NPL site action-leads, category type, and community group presence over time have failed to study how these factors were influenced by the implementation the SARA taxes (Probst et al. 2001; Probst 2017; Judy and Probst 2009). There has also been no study of the environmental justice implications of the taxes. While previous scholarship has revealed that there is a disproportionate number of hazardous waste sites located in non-white, Hispanic, and low-income communities, this research has not explored how the SARA tax expiration may have led to an inequitable prioritization of certain host communities (Bullard 1996; Burwell-Naney et al. 2013; Greenstone and Justin Gallagher 2008; Hird 1993; Maranville et al. 2009; UCC 1987). My research seeks to fill these gaps in scholarship through analyzing how NPL site-specific attributes and embeddedness in certain types of communities, changed as a result of the SARA taxes' expiration. This will not only provide greater insight into the equity and effectiveness of the taxes, but also help uncover, at a broader scale, how regulatory agencies' funding resources connect to their implementation results.

Data and Methods

Data Sources

To compare the characteristics of sites deleted from the NPL before and after the SARA taxes' expiration (1991-1996 and 1997-2002) in EPA Region 5, I mainly utilize attribute data from the EPA's "Superfund Archived Data and Reports." The EPA releases this publicly available data on Superfund site assessments, remediation actions, and status to enable researchers, stakeholders, policymakers, and those affected by sites to easily access site-specific information.[2] In my research, I also use U.S. Census Bureau data including EPA Region 5 census tract boundaries, per capita income, and race and ethnicity data acquired through IPUMS National Historical Geographic Information System (NHGIS), which formats these historical data files for use in GIS software. Point data representing NPL site locations from NASA's Socioeconomic Data and Applications Center is used for spatial analysis methods.

Attribute Data

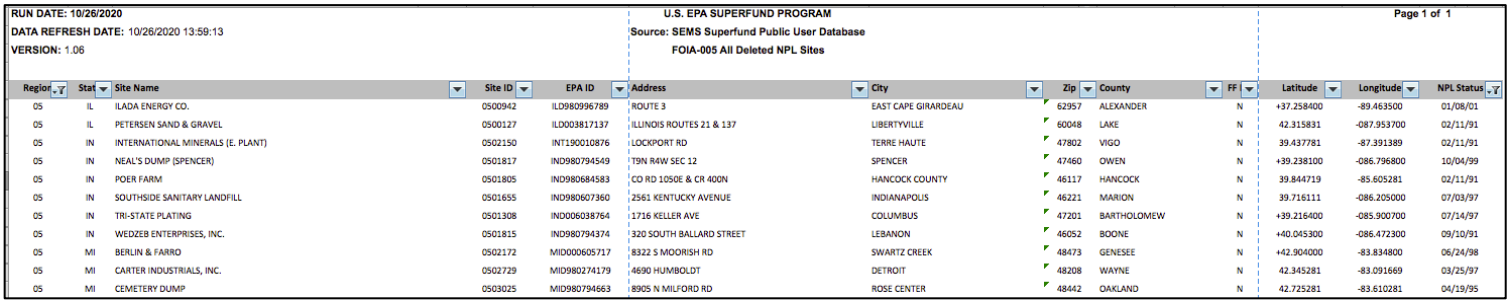
EPA Superfund Archived Data and Reports

In my analysis I use three EPA Superfund datasets including "All current Final NPL Sites (FOIA 4)," "All current Deleted NPL Sites (FOIA 5)," and "SCAP 12-NPL SITES." "All current Final NPL Sites (FOIA 4)" and "All current Deleted NPL Sites (FOIA 5)" are large datasets presented in an excel format containing information on the region, state, site name, site ID, EPA ID, address, city, zip, county, latitude and longitude, and NPL status year of all final and deleted NPL sites. This data file can be filtered by region and date of NPL status allowing me to pull

[2] US EPA, OLEM. "Superfund Data and Reports." Reports and Assessments. US EPA, February 12, 2015. https://www.epa.gov/superfund/superfund-data-and-reports.

only the sites in Region 5 from 1991-1996 and 1997-2002. When sorted, there are 57 Region 5 NPL sites from these years (EPA, 2013). A snapshot of this data source is provided in Figure 10.

Figure 10: Snapshot of "All current Deleted NPL Sites (FOIA 5)" from EPA Superfund Archived Data and Reports

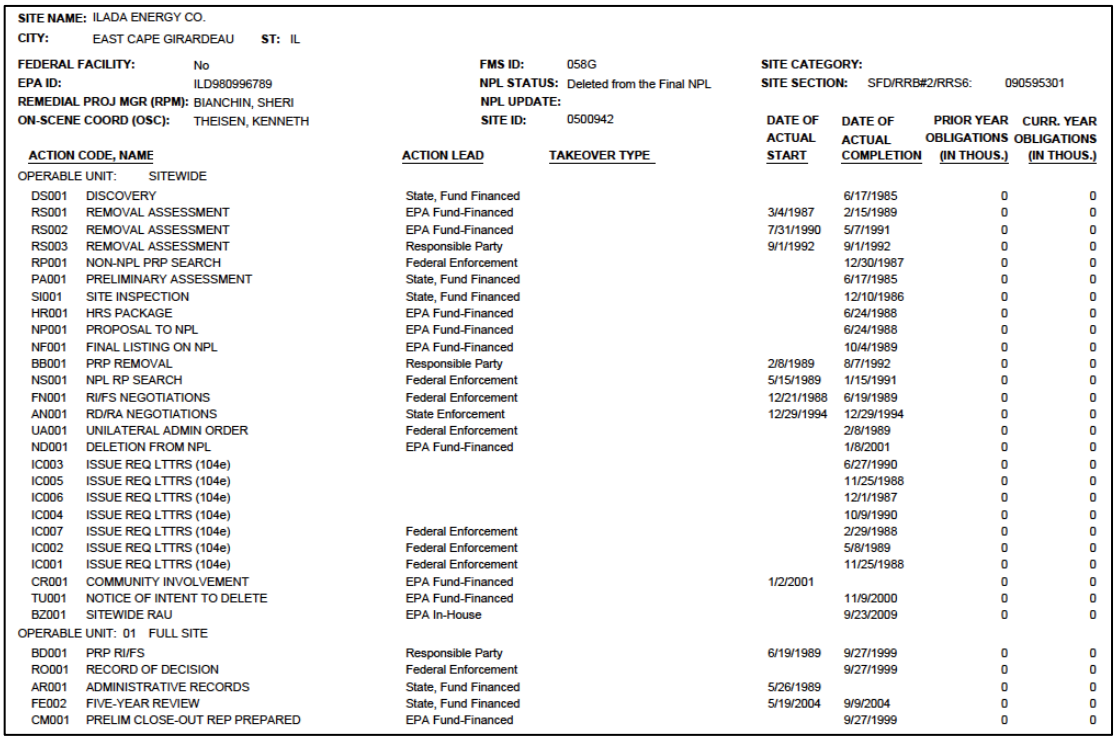


RUN DATE: 10/26/2020 — U.S. EPA SUPERFUND PROGRAM — Page 1 of 1
DATA REFRESH DATE: 10/26/2020 13:59:13 — Source: SEMS Superfund Public User Database
VERSION: 1.06 — FOIA-005 All Deleted NPL Sites

Region	State	Site Name	Site ID	EPA ID	Address	City	Zip	County	FF	Latitude	Longitude	NPL Status
05	IL	ILADA ENERGY CO.	0500942	ILD980996789	ROUTE 3	EAST CAPE GIRARDEAU	62957	ALEXANDER	N	+37.258400	-89.463500	01/08/01
05	IL	PETERSEN SAND & GRAVEL	0500127	ILD003817137	ILLINOIS ROUTES 21 & 137	LIBERTYVILLE	60048	LAKE	N	42.315831	-087.953700	02/11/91
05	IN	INTERNATIONAL MINERALS (E. PLANT)	0502150	INT190010876	LOCKPORT RD	TERRE HAUTE	47802	VIGO	N	39.437781	-87.391389	02/11/91
05	IN	NEAL'S DUMP (SPENCER)	0501817	IND980794549	T9N R4W SEC 12	SPENCER	47460	OWEN	N	+39.238100	-086.796800	10/04/99
05	IN	POER FARM	0501805	IND980684583	CO RD 1050E & CR 400N	HANCOCK COUNTY	46117	HANCOCK	N	39.844719	-85.605281	02/11/91
05	IN	SOUTHSIDE SANITARY LANDFILL	0501655	IND980607360	2561 KENTUCKY AVENUE	INDIANAPOLIS	46221	MARION	N	39.716111	-086.205000	07/03/97
05	IN	TRI-STATE PLATING	0501308	IND006038764	1716 KELLER AVE	COLUMBUS	47201	BARTHOLOMEW	N	+39.216400	-085.900700	07/14/97
05	IN	WEDZEB ENTERPRISES, INC.	0501815	IND980794374	320 SOUTH BALLARD STREET	LEBANON	46052	BOONE	N	+40.045300	-086.472300	09/10/91
05	MI	BERLIN & FARRO	0502172	MID000605717	8322 S MOORISH RD	SWARTZ CREEK	48473	GENESEE	N	+42.904000	-83.834800	06/24/98
05	MI	CARTER INDUSTRIALS, INC.	0502729	MID980274179	4690 HUMBOLDT	DETROIT	48208	WAYNE	N	42.345281	-83.091669	03/25/97
05	MI	CEMETERY DUMP	0503025	MID980794663	8905 N MILFORD RD	ROSE CENTER	48442	OAKLAND	N	42.725281	-83.610281	04/19/95

The archived report "SCAP 12-NPL SITES," describes the sequence of activities undertaken at all NPL sites in addition to funding information on remedial pipeline actions and site characterization data as seen in Figure 11. Specifically, this data offers information on NPL sites' action code name, number and type of activities conducted at each operable unit, the party that funded operable unit actions, and the start and completion date of actions. Other characterization information within the dataset includes the name of the remedial project manager, site category, NPL status, and site and EPA ID. The data is presented through a PDF and a downloadable xlsx file where data can be sorted by its EPA Region and identified by its EPA ID. The NPL sites listed span from the earliest sites in the Superfund program up to those on the NPL in 2013. The information on operable unit actions, action leads, and site category are unique to this SCAP-12 NPL SITES dataset and are not provided in the previously discussed FOIA 4 and FOIA 5 files. Together, both EPA archival reports provide site characterization and funding data needed to study how NPL site-specific attributes and remediation actions change over the SARA taxes expiration threshold (EPA, 2013).

Figure 11: Snapshot of "SCAP 12-NPL SITES" from EPA Superfund Archived Data and Reports



SITE NAME: ILADA ENERGY CO.
CITY: EAST CAPE GIRARDEAU **ST:** IL

FEDERAL FACILITY: No
EPA ID: ILD980996789
REMEDIAL PROJ MGR (RPM): BIANCHIN, SHERI
ON-SCENE COORD (OSC): THEISEN, KENNETH

FMS ID: 058G
NPL STATUS: Deleted from the Final NPL
NPL UPDATE:
SITE ID: 0500942

SITE CATEGORY:
SITE SECTION: SFD/RRB#2/RRS6: 090595301

ACTION CODE, NAME		ACTION LEAD	TAKEOVER TYPE	DATE OF ACTUAL START	DATE OF ACTUAL COMPLETION	PRIOR YEAR OBLIGATIONS (IN THOUS.)	CURR. YEAR OBLIGATIONS (IN THOUS.)
OPERABLE UNIT:	SITEWIDE						
DS001	DISCOVERY	State, Fund Financed			6/17/1985	0	0
RS001	REMOVAL ASSESSMENT	EPA Fund-Financed		3/4/1987	2/15/1989	0	0
RS002	REMOVAL ASSESSMENT	EPA Fund-Financed		7/31/1990	5/7/1991	0	0
RS003	REMOVAL ASSESSMENT	Responsible Party		9/1/1992	9/1/1992	0	0
RP001	NON-NPL PRP SEARCH	Federal Enforcement			12/30/1987	0	0
PA001	PRELIMINARY ASSESSMENT	State, Fund Financed			6/17/1985	0	0
SI001	SITE INSPECTION	State, Fund Financed			12/10/1986	0	0
HR001	HRS PACKAGE	EPA Fund-Financed			6/24/1988	0	0
NP001	PROPOSAL TO NPL	EPA Fund-Financed			6/24/1988	0	0
NF001	FINAL LISTING ON NPL	EPA Fund-Financed			10/4/1989	0	0
BB001	PRP REMOVAL	Responsible Party		2/8/1989	8/7/1992	0	0
NS001	NPL RP SEARCH	Federal Enforcement		5/15/1989	1/15/1991	0	0
FN001	RI/FS NEGOTIATIONS	Federal Enforcement		12/21/1988	6/19/1989	0	0
AN001	RD/RA NEGOTIATIONS	State Enforcement		12/29/1994	12/29/1994	0	0
UA001	UNILATERAL ADMIN ORDER	Federal Enforcement			2/8/1989	0	0
ND001	DELETION FROM NPL	EPA Fund-Financed			1/8/2001	0	0
IC003	ISSUE REQ LTTRS (104e)				6/27/1990	0	0
IC005	ISSUE REQ LTTRS (104e)				11/25/1988	0	0
IC006	ISSUE REQ LTTRS (104e)				12/1/1987	0	0
IC004	ISSUE REQ LTTRS (104e)				10/9/1990	0	0
IC007	ISSUE REQ LTTRS (104e)	Federal Enforcement			2/29/1988	0	0
IC002	ISSUE REQ LTTRS (104e)	Federal Enforcement			5/8/1989	0	0
IC001	ISSUE REQ LTTRS (104e)	Federal Enforcement			11/25/1988	0	0
CR001	COMMUNITY INVOLVEMENT	EPA Fund-Financed		1/2/2001		0	0
TU001	NOTICE OF INTENT TO DELETE	EPA Fund-Financed			11/9/2000	0	0
BZ001	SITEWIDE RAU	EPA In-House			9/23/2009	0	0
OPERABLE UNIT: 01	FULL SITE						
BD001	PRP RI/FS	Responsible Party		6/19/1989	9/27/1999	0	0
RO001	RECORD OF DECISION	Federal Enforcement			9/27/1999	0	0
AR001	ADMINISTRATIVE RECORDS	State, Fund Financed		5/26/1989		0	0
FE002	FIVE-YEAR REVIEW	State, Fund Financed		5/19/2004	9/9/2004	0	0
CM001	PRELIM CLOSE-OUT REP PREPARED	EPA Fund-Financed			9/27/1999	0	0

U.S. Census Bureau Data by Census Tract, Decennial Census 1990 and 2000 Acquired through IPUMS NHGIS

In my analysis, I use socioeconomic and demographic data from the Decennial U.S. Census for the years 1990 and 2000 to observe the characteristics of the population in close proximity to NPL Superfund sites. The variables that I am specifically interested in include per capita income, percent white, nonwhite, and Hispanic by census tract. The choice to focus on this data was informed by multiple environmental justice studies evaluating the community demographics surrounding Superfund sites, which found that race, ethnicity, and income significantly influence where hazardous waste sites are located (Burwell-Naney 2013; Maranville et al. 2009; UCC 1987). Using these environmental justice studies as a framework, my research explores whether these same community demographics impacted a site's likelihood for cleanup after the SARA taxes expired. Studying the racial, ethnic, and income composition of communities with deleted NPL sites enables me to contextualize my research

within the environmental justice framework. Thus, given my findings, I can make more meaningful conclusions about the equity of the taxes. The relevant datasets were accessed through the IPUMS NHGIS Data Finder. Each dataset contains Decennial Census 1990 and 2000 variable counts by census tract for the entire nation. Excel tables for each of these years were downloaded separately from the NHGIS Data Extract (U.S. Census, 1990; U.S. Census, 2000).

Spatial Data

The U.S. Environmental Protection Agency (EPA) National Priorities List (NPL) Sites Point Data with CIESIN Modifications, Version 2 (2014)

The spatial data "The EPA NPL Sites Point Data with CIESIN Modifications, Version 2 (2014)," was made public by NASA's Socioeconomic Data and Applications Center (SEDAC) and the Center for International Earth Science Information Network (CIESIN) at Columbia University to provide corrected georeferenced data for 1,747 National Priorities List (NPL) Superfund sites across the U.S. and territories. The dataset includes NPL sites that are proposed, final, and deleted under the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) since February 27, 2014. It is important to note that this data reflects the current status of NPL sites as of 2014. Thus, final sites that were fully remediated at any point during this period have been overwritten as "deleted." EPA's NPL site dataset was modified by the CIESIN as eleven sites needed latitude and longitude corrections making the dataset more accurate and therefore better suited for my analysis. Additionally, the NPL point information also contains site characteristics such as NPL status, site name, address,

state, and EPA region, making it easy to sort for my years and sites of interest. This data is accessible at the SEDAC "Superfund Footprint" site (CIESIN, 2014).[3]

U.S. Census Bureau Cartographic Boundary Files – Shapefile – Census Tracts 1990, 2000 Acquired through IPUMS NHGIS

This spatial data was accessed and downloaded from the IPUMS NHGIS Data Finder as shapefiles (a geospatial vector data format that includes spatial and attribute data) of U.S. Census tracts for the Decennial Census years 1990 and 2000. These shapefiles are the U.S. Census' cartographic boundary files TIGER line (NHGIS, 2020).

Limitations with Chosen U.S. Census Data

Given that my research is specifically focused on comparing NPL site host community demographics and remediation results for the years 1991-1996 and 1997-2002, the Decennial Census representing per capita, race, and ethnicity data by census tract for only 1990 and 2000, do not provide the perfect match for my analysis. 5-year American Community Survey data would have been the ideal dataset but is only available from 2005 onwards. Despite this, the Decennial Census data is the best data available for my research as it, most importantly, includes data from before and after the SARA tax expiration threshold. Additionally, census tract-level data for one year can include margins of error that may not be as significant on less granular levels. Thus, these values by census tract may be an over or under estimate. Yet, using

[3] United States Environmental Protection Agency-US EPA, National Institute For Environmental Health Sciences Columbia University Superfund Research Program-NIEHS CU SRP, and Center For International Earth Science Information Network-CIESIN-Columbia University. "U.S. EPA National Priorities List (NPL) Sites Point Data with CIESIN Modifications, Version 2." Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC), 2014. https://doi.org/10.7927/H44X55RB.

county-level data would not yield accurate results as counties are often much larger than the area in close proximity to NPL Superfund sites.

Methodology

Attribute data collection and analysis

To examine the impact of the SARA taxes on remediation outcomes, focusing specifically EPA Region 5 including Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin, I employed a number of data analysis tools. Data from the EPA's "SCAP 12-NPL SITES," "All current Final NPL Sites (FOIA 4)," and "All current Deleted NPL Sites (FOIA 5)" was collected and combined into a new dataset containing only information on Region 5 NPL final and deleted sites from 1991-1996 and 1997-2002. This new dataset includes NPL site characterization data such as information on the site state, name, ID, EPA ID, address, city, coordinates, month and year of cleanup, category, federal facility status, operable unit number and completion of cleanup date. Information on community engagement presence (indicated in operable unit actions SCAP-12 NPL SITES), total actions undertaken, and percentage of actions led by the EPA Trust Fund, potentially responsible parties (PRPs), federal enforcements, states, and other entities will also be included (EPA, 2013). Once all this information was collected and cataloged, I separated the data into four main groupings: deleted NPL sites 1991-1996, final NPL sites 1991-1996, deleted NPL sites 1997-2002, and final NPL sites 1997-2002. These groupings allow me to directly compare sites remediated before and after the SARA tax expiration, while accounting for underlying trends that may be occurring across the program during these periods. Thus, the data on the final NPL sites serve as a "control" and are analyzed in parallel with deleted NPL sites.

To first get a sense of patterns that arise in each group before and after 1996, I used simple bar charts and pie charts to visually represent the distribution of how site characteristics have changed over the tax expiration threshold. Using the information provided by the bar and pie charts, I make conclusions about how the SARA taxes affected remediation decisions and outcomes. Through this analysis, I gain a greater understanding of what types of Superfund sites were prioritized before and after the taxes' expiration in EPA Region 5. What types of stakeholders were involved at the sites that were cleaned up? Were community groups or PRPs more prevalent before or after the taxes' expiration or was there no significant change? What types of EPA category sites received the most attention? Were more expensive sites with sediment or groundwater contaminants, for example, avoided after the trust fund dwindled? My methodological approach seeks to directly answer these questions.

Spatial analysis

The goal of my spatial analysis is to: 1) create density maps of Region 5 final and deleted NPL sites from 1991-1996 and 1997-2002; 2) use the density maps to identify NPL sites hotspots; 3) analyze the average per capita income, average percent white, nonwhite, and Hispanic by census tract of Superfund host communities; 4) compare the spatial patterns surrounding deleted sites from 1991-1996 to deleted sites from 1997-2002 to gain insight into whether the SARA tax expiration affected the types of host communities that received full remediation action at their NPL site(s).

In order to compare community demographics surrounding deleted NPL sites in Region 5 from before and after the SARA tax expiration, I set up a comparative analysis of final and deleted NPL sites host community characteristics for the years 1991-1996 and 1997-2002 by

grouping all the spatial and attribute data for each time period separately. Since this analysis is most concerned with the demographics of host communities with fully remediated sites i.e. deleted NPL sites, the final NPL sites i.e. sites awaiting full cleanup, serve as a "control" group so changes influenced mainly by the SARA taxes can be better identified.

Step 1: Region 5 and Point Layers

In QGIS, I first imported the 1990 U.S. Census Tract shapefile and selected the EPA Region 5 states including Illinois, Wisconsin, Indiana, Michigan, Minnesota, and Ohio and created a new layer. Next, I sorted and cleaned the "EPA NPL Sites Point Data with CIESIN Modifications, Version 2 (2014)" dataset to only contain information for Region 5 final NPL sites from 1983-1996, deleted NPL sites from 1991-1996, final NPL sites from 1983-2002, and deleted NPL sites from 1997-2002. It was important to include all sites on the final NPL up until 1996 and 2002, since sites that remain on this list during these time periods have not reached full remediation and thus serve as the "control." Once this data was sorted, I imported it into QGIS using the longitude and latitude coordinates to create a point layer. I then selected for deleted NPL and final NPL sites separately, exporting both as separate point layers.

Step 2: Kernel Density Estimation Mapping

After having both Region 5 and final and deleted NPL site point layers projected, I employed a kernel density estimation (KDE) (heatmapping) to identify hotspots of NPL sites during the 1991-1996 and 1997-2002 time periods. Using KDE here was key to evaluating the density of these sites that could not be accurately inferred from just looking at the point clustering. This is important for gaining understanding where the majority of NPL sites reside in

Region 5 during these time periods, especially if there is a disproportionate amount in one area. Once these hotspots were identified, I could better hone in on the per capita income, race, and ethnicity distributions at these locations. I created four density maps: two with deleted sites and two with final sites for each time period before and after the SARA tax expiration. For a less busy cartographic map, I made the census tract boundaries of the Region 5 layer transparent here since these tracts were not need in this stage of the analysis. These maps are presented later in the "*Kernel Density Estimation Maps"* section of my study.

Step 3: Buffer Layer

Next in my spatial analysis, I created a 3-mile buffer around each of the final and deleted NPL site point layers. A 3-mile buffer distance was used to analyze characteristics of Superfund site host communities in an EPA study (EPA 2020); for this reason, a 3-mile distance was also utilized here. However, it is important to note that these buffers are not reflective of the specific community that may be exposed to hazardous waste at an NPL Superfund site. Instead, the buffer provides a uniform way to assess populations in close proximity to the site (EPA, 2020). I chose to dissolve these buffers, as there was no need to have the boundaries of overlapping buffers intersect. This intersecting would create a double-counting of census tracts when calculating the average percentages of the per capita income, race, and ethnicity of host communities in close proximity to multiple sites.

Step 4: Thematic Mapping

Working with the EPA Region 5 census tract layer, I imported cleaned 1990 and 2000 per capita income, race, and ethnicity data attribute tables and then joined them to the

corresponding EPA Region 5 census tracts 1990 and 2000 shapefiles, in order to connect the non-spatial census attribute data to the spatial Region 5 census tract data. This step is integral to creating a thematic map as each census tract demographic count is now connected to a spatial census tract polygon within Region 5. Using the Field Calculator function, I converted these variables into a double/real number since they were imported as strings which does not allow for a thematic map to be created or for percentages of variables to be calculated. I also used the Field Calculator to divide the aggregate counts of white, nonwhite, and Hispanic by the total population within each corresponding census tract. This enabled me to create a percentage variable to map rather than merely just mapping a count variable which would incorrectly exclude the underlying population.

Step 5: Intersection

Using the buffer layers for final and deleted sites 1991-1996 and 1997-2002 and the corresponding EPA Region 5 with attribute data on per capita income, percent white, nonwhite, and Hispanic, I intersected the two layers containing only the census tracts within the buffers. Note that each separate buffer layer, the layer for final sites (1991-1996 and 1997-2002) and the layer for deleted sites (1991-1996 and 1997-2002), were intersected separately with EPA Region 5. This geoprocessing allowed me to solely view the characteristics of host communities enabling them to be more easily compared. Each intersection layer can be transformed into a thematic map displaying the distribution of socioeconomic and racial attribute data within census tracts near NPL sites. Approximately the same scale was used for each map throughout the analysis.

After analyzing each site from 1991-2002 in Region 5, both those completely remediated and those still awaiting full remediation, I identified if any patterns arose in the data. This enabled me to determine if the SARA taxes had a causal effect on remediation results at NPL sites.

To evaluate the validity my research results, I contextualize my data analysis findings within scholarship on trends in the Superfund program from 1990s to 2000s. Although remediated Superfund sites have not been examined on this granular of a level in relation to the SARA taxes, scholarly experts have weighed in on the possible effect of their expiration. Using these existing reports, I evaluate if my findings fit within the narrative of Superfund progress and cleanup results during and after the taxes.

Findings: NPL Site-Specific Attribute Data

In my data collection and analysis, I evaluated site-specific attributes of final and deleted NPL sites while the SARA taxes were in effect and after they expired to examine their impact on remediation results in EPA Region 5. Identifying shifts in site categories, action leads, remedial design and action leads, and community involvement distributions are key to understanding how Superfund's trust fund balance can influence what types of sites are prioritized for remediation. While the regional scope of my research allows for an in-depth analysis of this relationship, it is limited by a smaller sample size of 54 deleted NPL sites in total and 425 final NPL sites in total. This has implications for the interpretation of my findings as small shifts in certain site characteristics alone are likely not enough to attribute to the SARA taxes, but rather, hold more meaning when put in conversation with one another.

Site Categories

In my data analysis, I studied the number and types of different categories of sites present on the Final NPL from 1991-1996 and 1997-2002 as well as the categories of sites deleted from the NPL in these years. This reveals if “cheaper” and “simpler” sites were favored after the SARA taxes expired. This shift would indicate that more stringent funds can influence the kinds of sites that receive remediation in EPA Region 5. First, it is necessary to assess the distribution of the final NPL sites across the tax threshold to determine if there are any changes in trends regarding site category that should be accounted for when evaluating the deleted NPL sites. As illustrated in the two bar charts below, the distribution of final site categories is similar in both graphs with landfill, manufacturing, missing site description, and industrial waste treatment as the leading four site types. This close similarity before and after the SARA taxes is due to only 5 final NPL sites added to the NPL from 1997-2002, four of which did not have data on-site type.

Figure 12

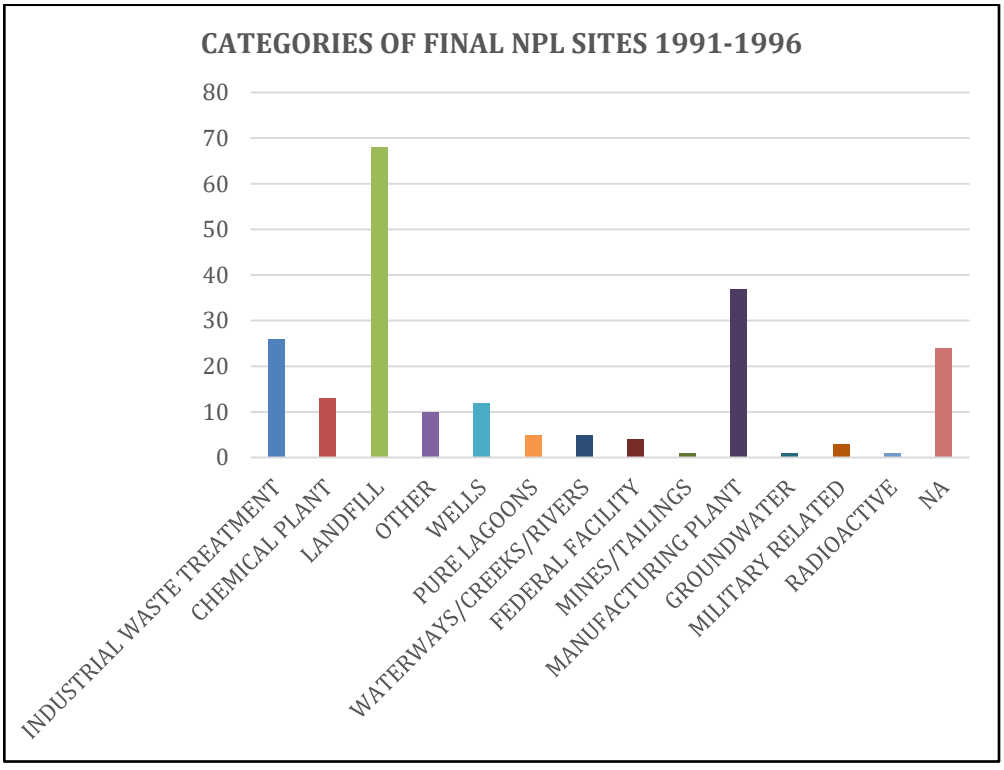


Figure 13

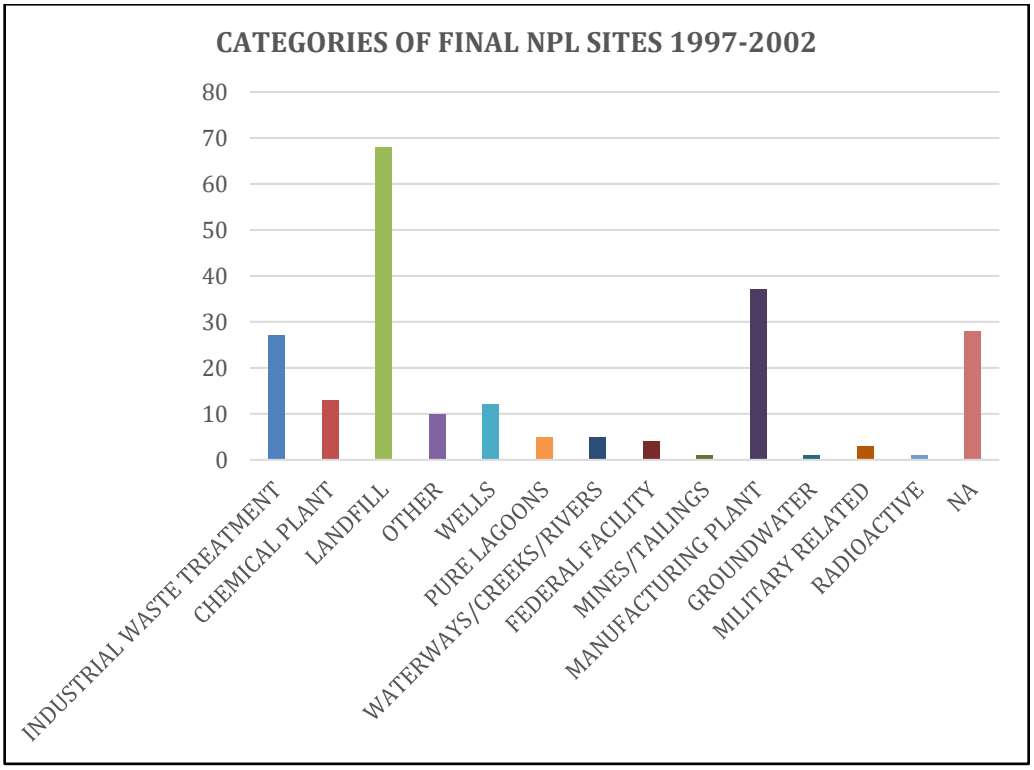


Figure 14

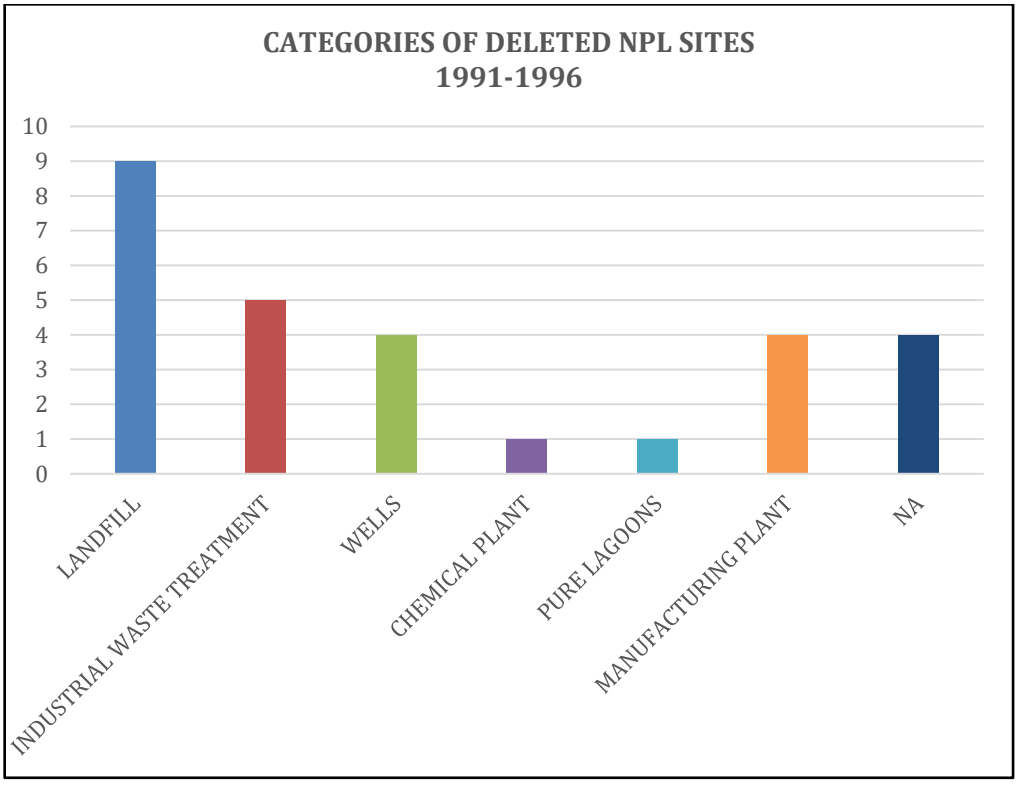
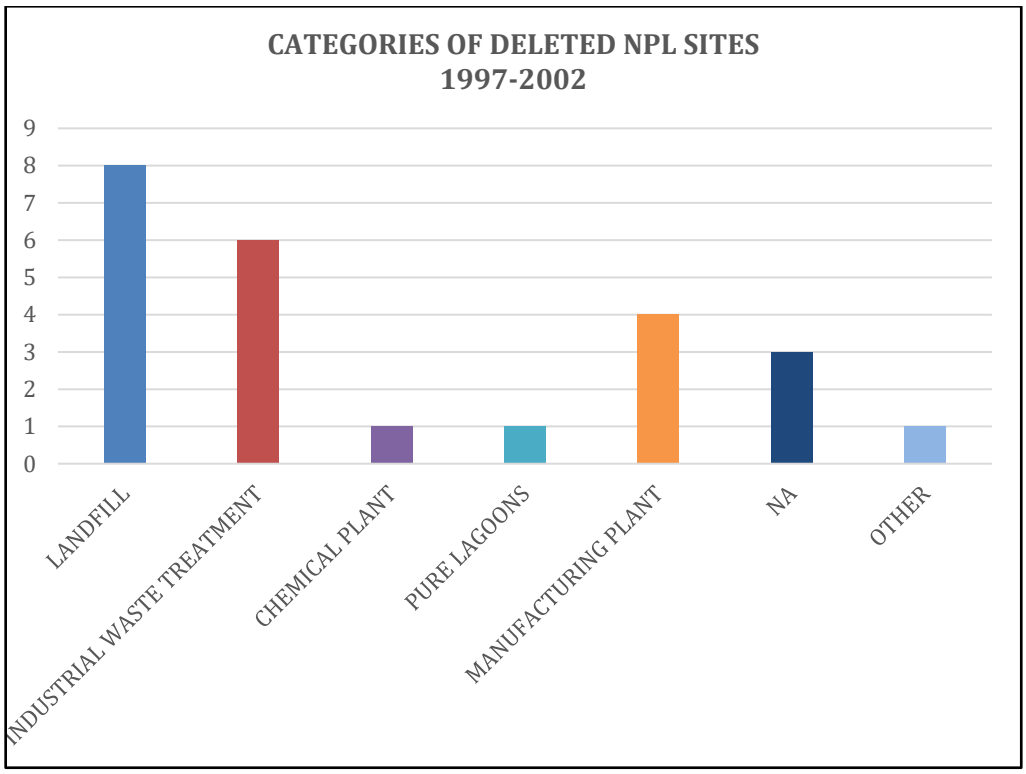


Figure 15



When assessing the deleted sites across the SARA tax expiration, there was not a substantial shift in site types, especially considering that only 54 sites were deleted from the NPL from 1991-2002. Both deleted NPL site types from 1991-1996 and 1997-2002 consist of mostly landfill and industrial waste treatment sites, with manufacturing plants not far behind. However, while the SARA taxes were in effect, a total of four wells sites were deleted whereas after their expiration, zero wells sites were deleted. While the sample size here is small, it is important to note that well sites involve groundwater contamination and are the most expensive sites to remediate (Probst 2017). This shift is the most significant among all the site types present in both time periods. Meanwhile, this change occurred while the number of wells sites on the final NPL were held constant over the tax expiration threshold at twelve wells sites. Thus, the absence of wells sites without the taxes could be attributed to avoidance of these sites due to their complicated and costly remediation implications.

Action Leads at NPL Sites

Evaluating the shift in action leads at NPL sites can provide insight into which funds are being used to remediate a site. Here, the action leads refer to cleanup-related actions at a site's operable units or designated regions where remediation is taking place. This thesis is mainly concerned with the proportion of fund money versus potentially responsible parties (PRP) funds used to cleanup NPL sites. When first analyzing the shift in action leads among final NPL sites across the tax expiration threshold (Figure 16) there is no change in action lead percentage. As previously mentioned, this is largely due to the small addition of new sites to the final NPL from 1997-2002. However, this limitation does not inhibit the analysis, as I am most interested in the changes occurring with deleted NPL sites and have, therefore, used the final NPL sites to identify any substantial differences between the site categories or tax years.

Figure 16: Action Leads at Final NPL Sites

Figure16a

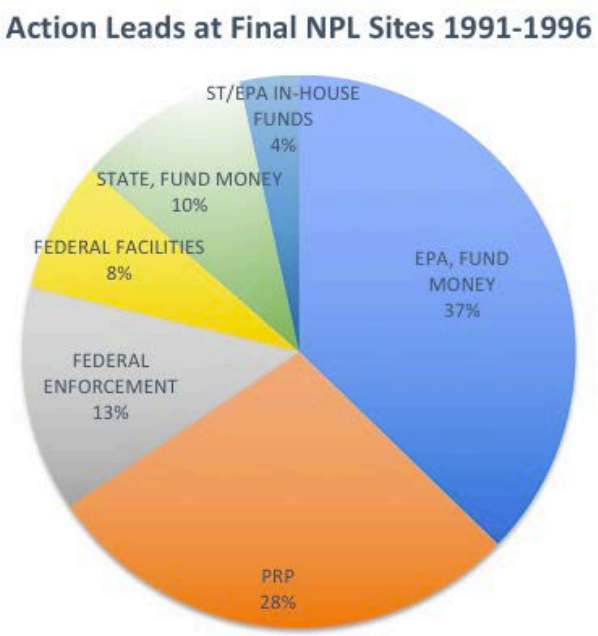


Figure 16b

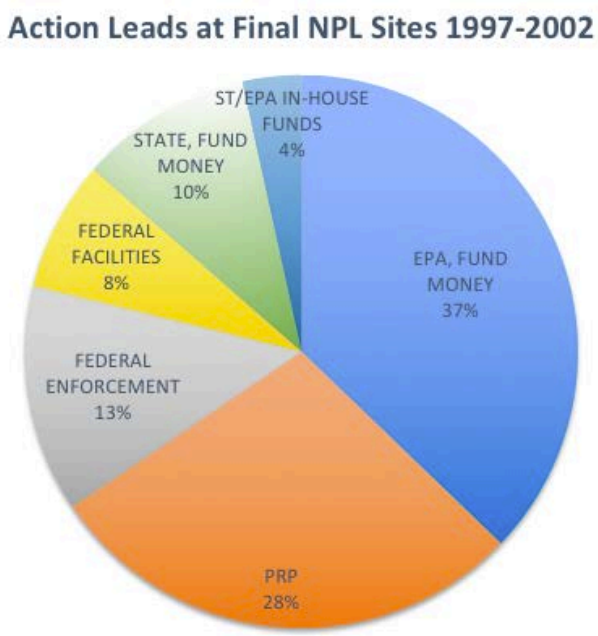


Figure: 17 Action Leads at Deleted NPL Sites

Figure 17a

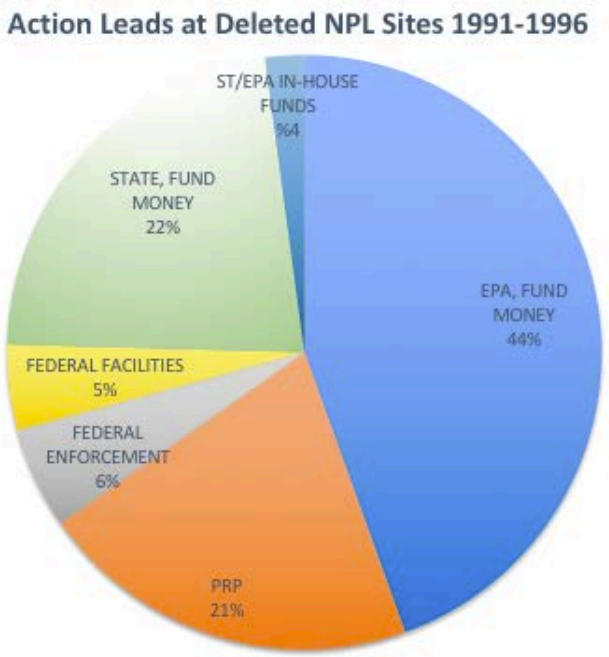


Figure 17b

Here, when analyzing the shift in action leads from 1991-1996 to 1997-2002, there does not appear to be a substantial shift in what funds are backing remediation efforts at these sites. However, from 1991-1996 state-led and EPA-led actions using trust fund money accounted for 66% of action leads, while in 1997-2002, the fund accounted for 56% of action leads (a 10% reduction). Meanwhile, there was an 8% increase in PRP funded actions in 1997-2002. These two findings indicate there was approximately 18% less actions funded by the trust fund across deleted NPL sites from 1996 onward, following the SARA tax expiration. This suggests that deleted sites requiring less fund money resources could have been potentially favored over sites that relied more heavily on these resources. This trend is consistent with the substantially lower trust fund balance after 1996. Thus, EPA Region 5 managers could be completing remediation at deleted sites with less fund requirements and more PRP presence, or these sites were the only ones deleted off the NPL during this time because the fund could not back sites without PRP leads. Whether this was deliberate or not, the trend as shown in the data, depicts that there is some sort of relationship between the tax expiration and the distribution of action leads at deleted NPL sites.

Stakeholder leads of remedial design and action at NPL sites

Figure 18: RD/Ras Leads at Final NPL Sites

Figure 18a

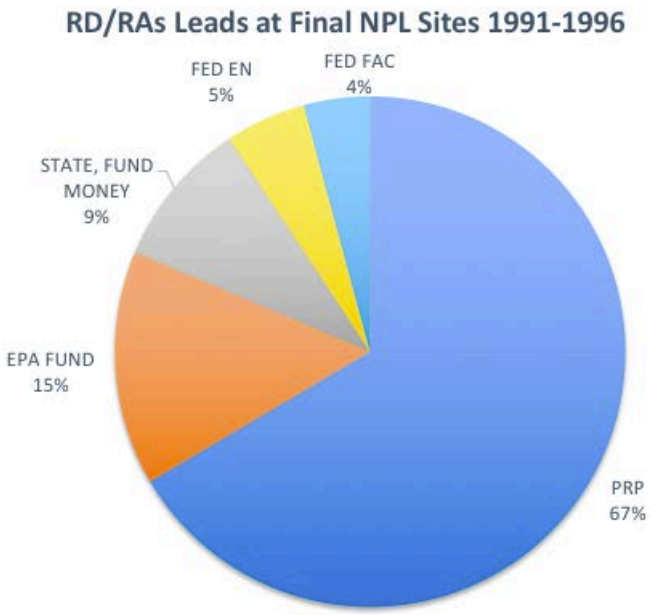


Figure 18b

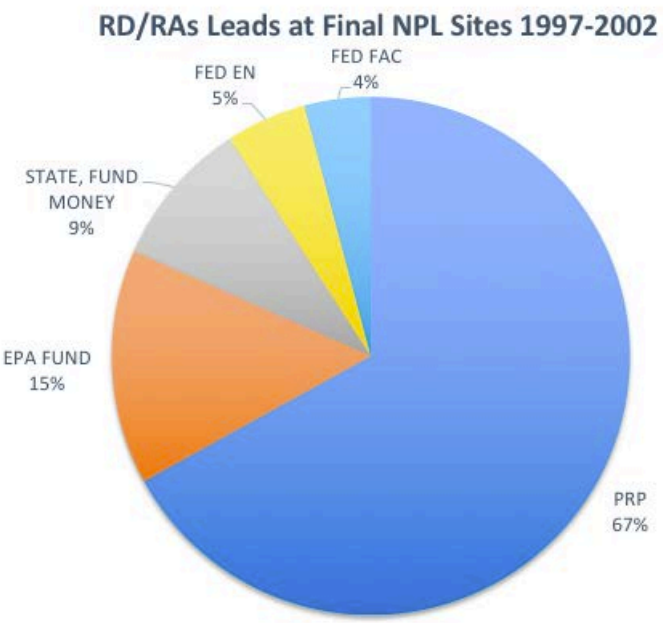


Figure 19: RD/RAs at Deleted NPL Sites

Figure 19a

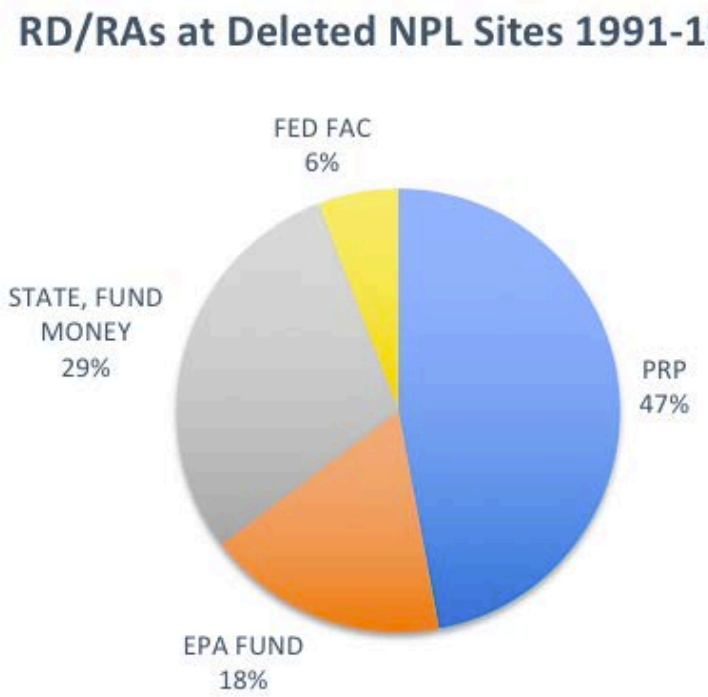
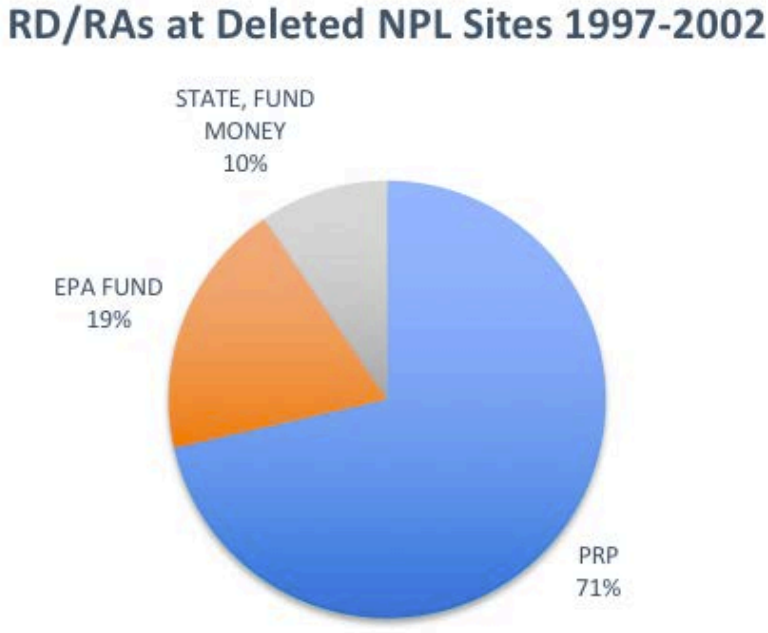


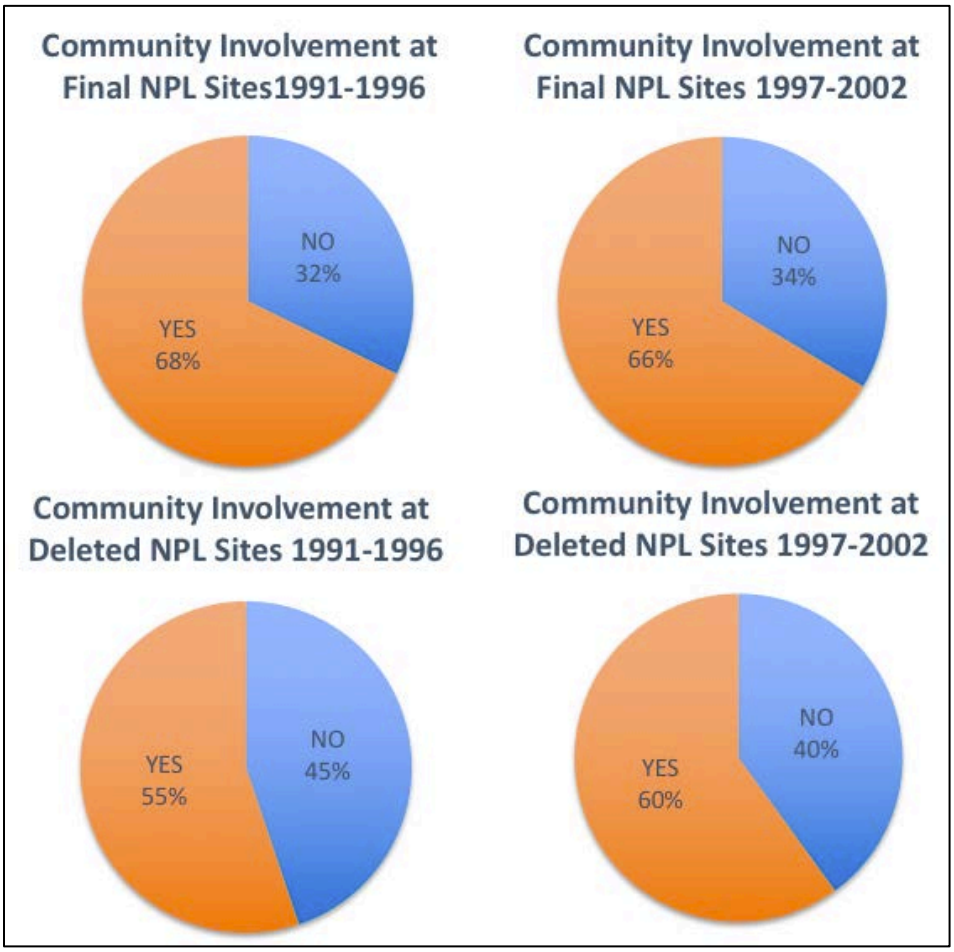
Figure 19b



Here, my findings on the distribution of remedial design and remedial action (RD/RAs) at NPL sites before and after the tax expiration are shown. RD/RAs refer to the actual cleanup actions at the site, representing the most expensive step in the remediation pipeline. As seen in these pie charts, there was a substantial shift in funding sources post-SARA in deleted NPL sites. While the taxes were in effect, the trust fund backed 47% of remediation efforts at deleted sites, the same percentage of PRP backed remediations. However, from 1997-2002, the trust fund accounted for only 29% of cleanups while PRPs backed 71%. With a smaller trust fund and no taxes bringing in revenue, it appears that sites with present and able PRPs were prioritized for cleanup or were the most able to be deleted from the NPL from 1997-2002. These findings are especially important to understanding how the SARA taxes impacted remediation results as RD/RAs completion is ultimately what enables sites to be cleaned up and no longer hazardous to the community. While the actual number of deleted NPL sites from 1991-1996 to 1997-2002 only decreased by 4 sites total, it is clear that funding resources did play a role in the which sites were officially removed from the Superfund during these time periods.

Community Involvement

Figure 20



When analyzing if community involvement was taking place at final and deleted NPL sites during these two time periods, there does not appear to be a substantial shift in trends across the SARA taxes expiration threshold. As previously discussed, it is important to look at community involvement at sites because it has been shown to increase the likelihood of a site's remediation (Daley 2007; Macey and Cannon 2007). I collected and analyzed this data to see if a small trust fund balance prompted more community involvement because under those circumstances, communities had to more actively mobilize to push remediation efforts.

While there is generally less community involvement in the deleted sites than final, this could be due to the small sample size of deleted sites in EPA Region 5 (54 sites in total) while final sites account for just under eight times more sites (425 sites in total). As shown, there is a 5% increase in community involvement at the sites that were deleted after tax expiration, however, again, this could just be because of the small sample.

Discussion: NPL site-specific attribute data

My site-specific attribute data findings of final and deleted NPL sites in Region 5 indicate that overall action-leads and community involvement did not substantially shift across the SARA tax expiration threshold, while changes did occur among site categories and stakeholder leads of remedial design and action. These findings suggest a tie between funding resources and remediation decisions as the expiration of the SARA taxes led to a significant drop in available funding resources. The absence of "wells" sites post-SARA potentially indicates that these notoriously expensive and complicated groundwater contamination sites were deliberately avoided due to a low trust fund balance. Concurrent with the SARA taxes from 1991-1996, there were four wells sites, whereas after their expiration (1997-2002 samples) there were zero—a change approximately four times more than any other change in site categories across these time periods. This finding indicates that a possible cherry picking of "cheaper" sites took place in Region 5 during this time. Additionally, there was a shift in remedial design and action leads during SARA compared to when it was no longer in effect. This can be seen in the trust fund backing 47% of remediation efforts at deleted sites, the same percentage of PRP backed remediations from 1991-1996. Yet, from 1997-2002, the trust fund accounted for only 29% of cleanups while PRPs backed 71%. This shift suggests that sites with

present and able PRPs were prioritized for cleanup or were the most able to be deleted from the NPL post-SARA taxes. Without the SARA taxes bringing in revenue, it is clear that their absence affected which sites were able to be remediated. While my study was not concerned with the relative danger different site types pose, this is a significant factor that must be considered especially if it appears that sites are being prioritized based off their associative costs, as seen here. With dangerous hazards on the line risking human and environmental health, the cost of a site should not be the main factor driving the likelihood of Superfund remediation.

Findings: spatial analysis of NPL site host community demographics

In the spatial analysis study, I analyzed the demographics of those living within 3 miles of Region 5 final and deleted NPL sites from 1991-2002 to determine whether or not the SARA taxes influenced which host communities had remediated sites. I specifically studied the racial, ethnic, and income composition of those in close proximity to the NPL sites including percent white, nonwhite, Hispanic, and per capita income. I highlight the results from my spatial analysis through the use of summary statistics where I compute the average among census tracts within a 3-mile radius around NPL sites. Before I discuss each of the spatial analysis findings, it is important to consider the underlying trends among these indicators within Region 5 census tracts as shown in Figure 21. It is also crucial to reiterate that using the 1990 and 2000 Decennial Census presents limitations because these year delineations do not exactly align with my years of focus during and post SARA. Still, these census years are the best data available and have proved sufficient for evaluating the change in demographics of NPL host communities over time.

Figure 21: Overall EPA Region 5 Trends

Overall EPA Region 5 trends	avg. % white	avg. % nonwhite	avg. % Hispanic	avg. per capita income
2000 Decennial Census	78.50%	18.57%	5.10%	$21,303.90
1990 Decennial Census	83.10%	16.45%	3.38%	$13,443.80
difference between years	-4.60%	2.12%	1.72%	$7,860.10

Kernel Density Estimation Maps

In my spatial analysis, I also assessed the density of final and deleted NPL sites to observe where sites were clustered. As depicted in the four kernel density estimation (KDE) maps, the Greater Minneapolis Area has the highest density of NPL Superfund sites both final and deleted from 1991-1996 and 1997-2002 (Figures 22-25). Employing KDE allowed for the identification and locating of the highest concentration of final NPL sites were since these tended to cluster within dense urban areas. Thus, for dense metropolitan hubs such as Minneapolis, Chicago, and Grand Rapids, the density maps demonstrated which region actually had the highest concentration of Superfund sites. For analyzing deleted NPL sites, which are far less numerous and more spatially dispersed, the KDE was less useful, but still allowed for the Great Minneapolis hotspot to be identified in both year ranges 1991-1996 and 1997-2002. These deleted sites did not appear to represent a distinct spatial pattern, but were instead, more or less, randomly distributed throughout Region 5. This indicates that there was likely not a prioritization of NPL sites by geographic area. Overall, producing these maps informed the next step of the analysis: comparing the per capita income of host communities before and after the SARA taxes at NPL site hotspots.

Density of Final and Deleted NPL Sites 1991-1996 and 1997-2002:

Figure 22

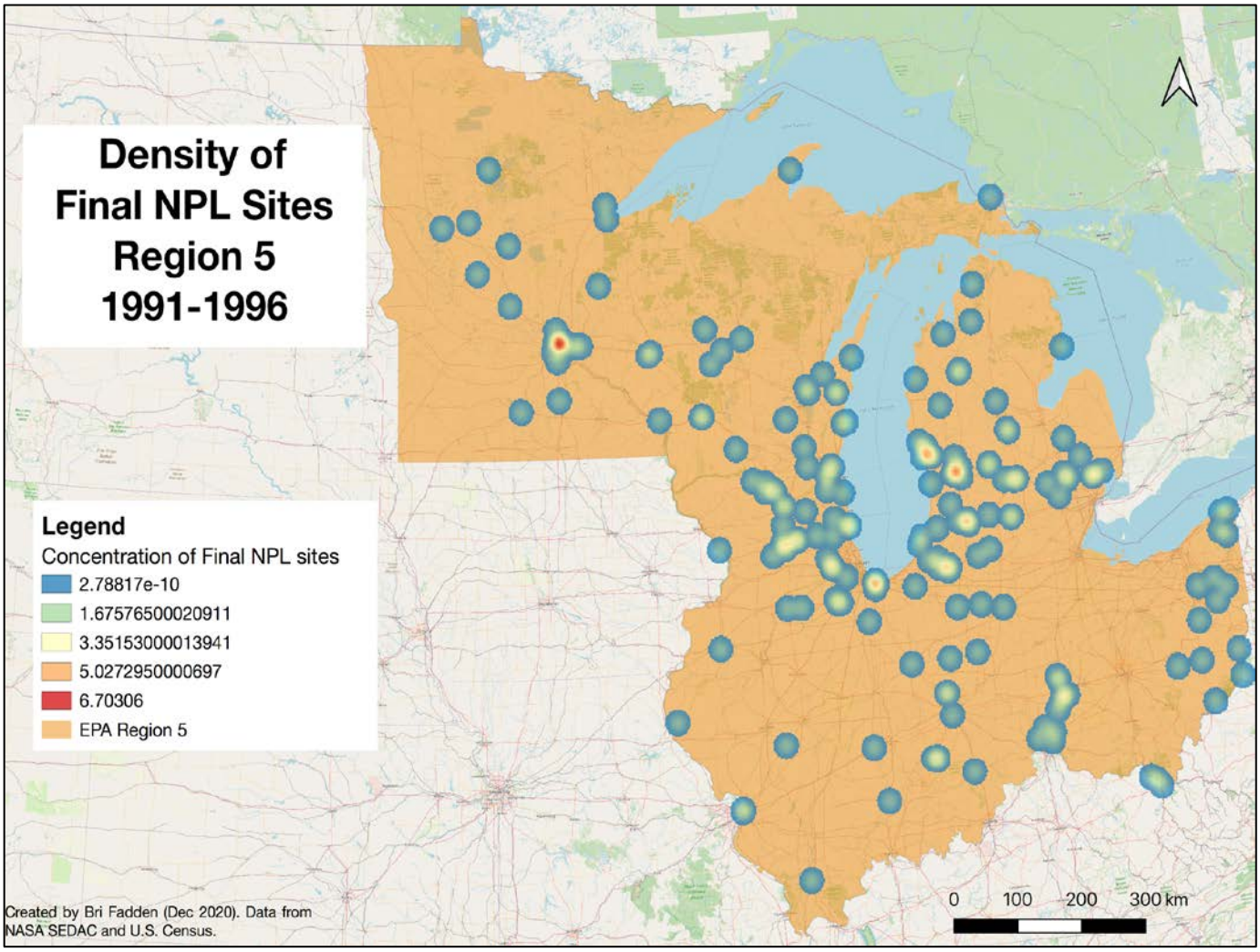


Figure 23

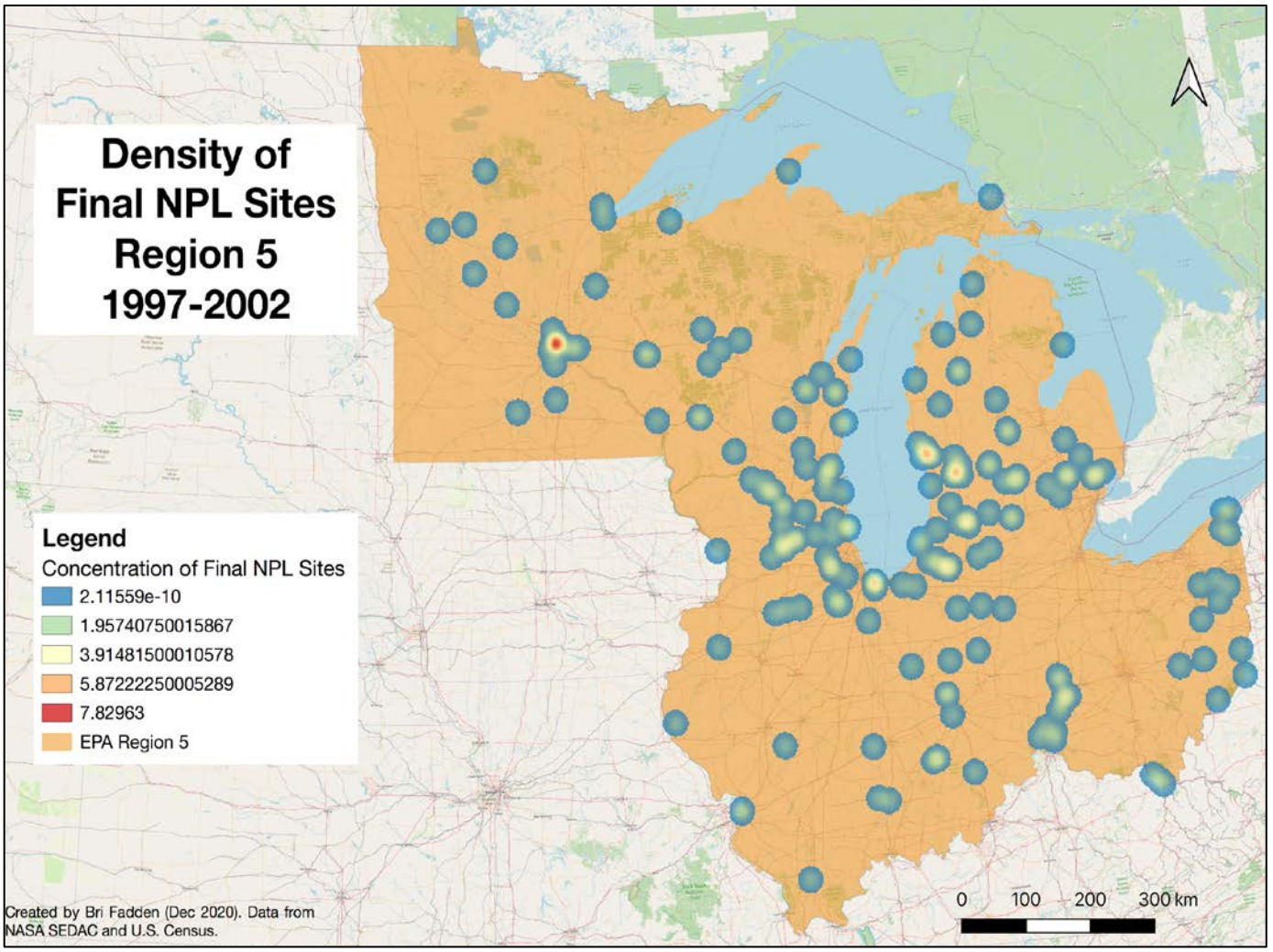

Density of
Final NPL Sites
Region 5
1997-2002
Legend
Concentration of Final NPL Sites
2.11559e-10
1.95740750015867
3.91481500010578
5.87222250005289
7.82963
EPA Region 5
Created by Bri Fadden (Dec 2020). Data from
NASA SEDAC and U.S. Census.
0
100
200
300 km

Figure 24

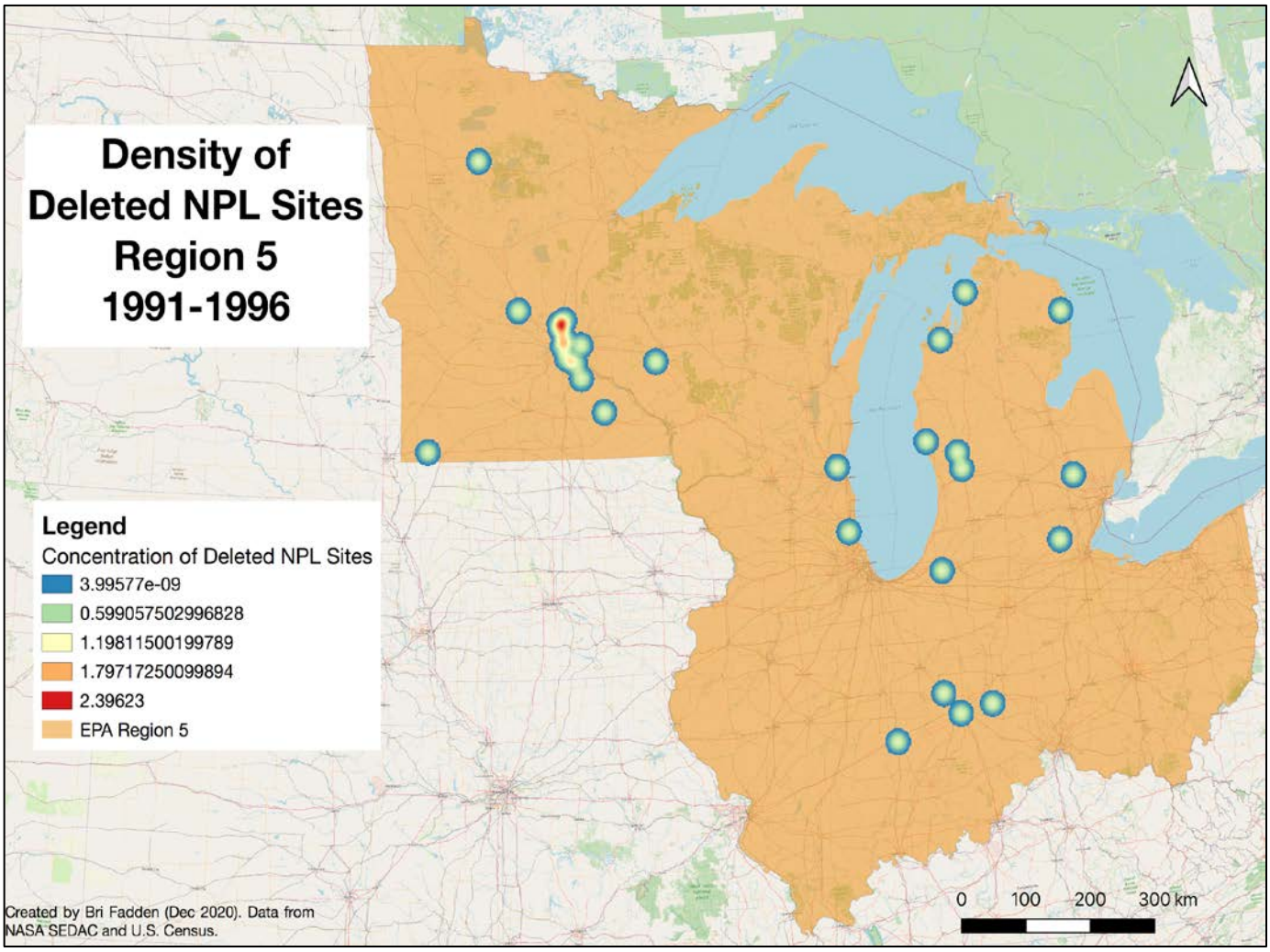
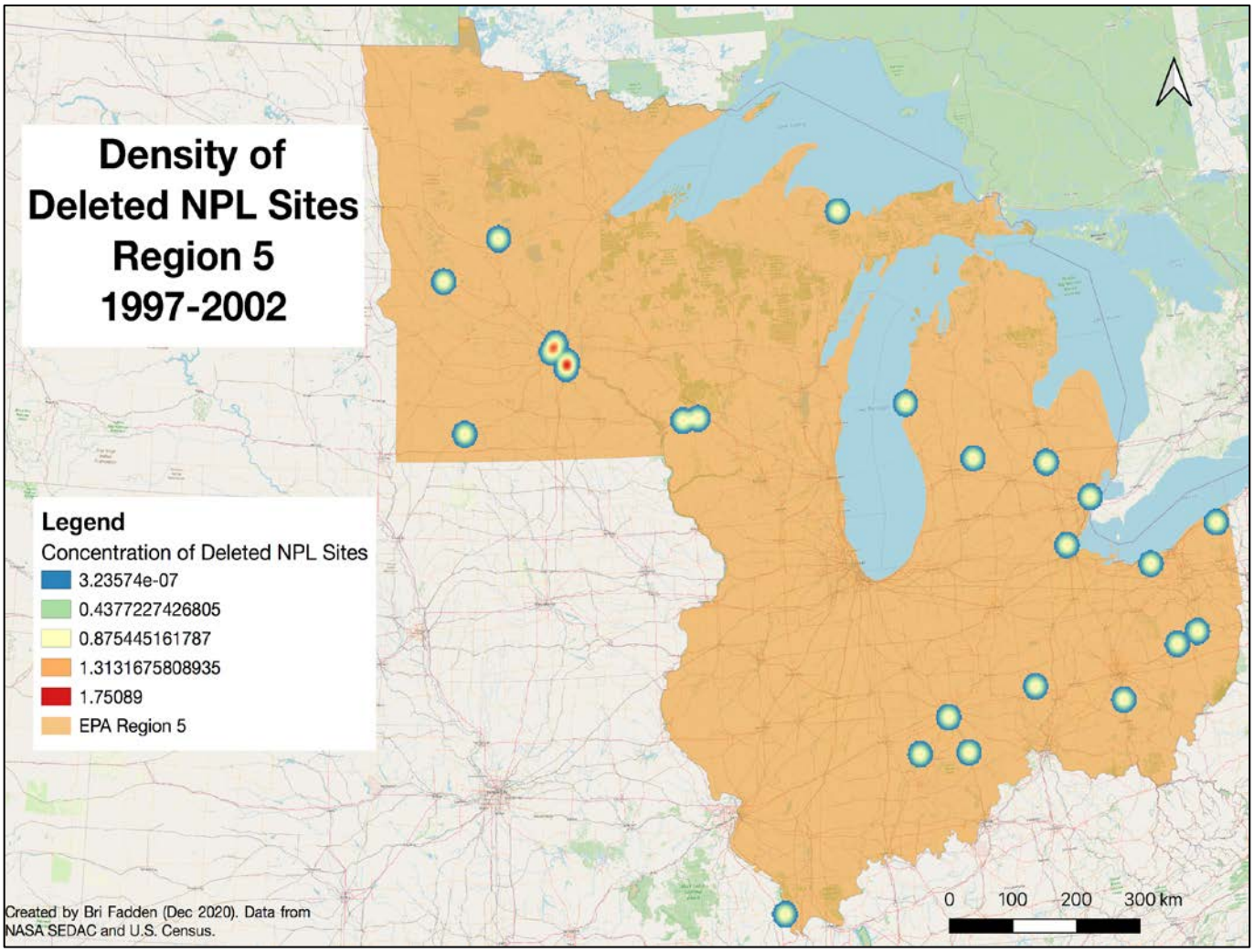

Density of
Deleted NPL Sites
Region 5
1991-1996
Legend
Concentration of Deleted NPL Sites
3.99577e-09
0.599057502996828
1.19811500199789
1.79717250099894
2.39623
EPA Region 5
Created by Bri Fadden (Dec 2020). Data from
NASA SEDAC and U.S. Census.
0
100
200
300 km

Figure 25



Average per capita income of census tracts within 3-miles of NPL sites

After analyzing the average per capita income of all census tracts within 3 miles of final and deleted NPL Superfund sites before and after the SARA tax expiration, there does not appear to be any substantial change in host communities' income level across the 1991-1996 to 1997-2002 threshold. This trend can be seen in Figure 26 which shows the difference between average per capita income of communities surrounding final NPL sites from 1991-1996 and 1997-2002 and then deleted NPL sites from 1991-1996 and 1997-2002.

Figure 26

per capita income	
final NPL sites	avg. within 3 mi buffers
1991-1996	$8,025.30
1997-2002	$12,139.10
deleted NPL sites	avg. within 3 mi buffers
1991-1996	$7,718.93
1997-2002	$11,958.70

Figure 27

Difference in avg. across SARA expiration threshold	
final NPL sites difference	$4,113.80
deleted NPL sites difference	$4,239.77
difference between final & del.	$125.97

Here, the summary statistics indicate that no substantial difference in the average per capita income of host communities among deleted sites occurred across the SARA tax expiration threshold (Figure 27). Both final and deleted sites experienced an approximate $4,000 increase in the period after the taxes' expiration. Thus, the deletion of NPL sites after the SARA tax expiration does not seem to have been influenced by the income of the surrounding site host community. Maps providing a snapshot of my spatial analysis results are shown in Figures 28-31. Maps of my other variables including percent white, percent nonwhite, and percent Hispanic will not be shown in the following sections since summary statistics, as presented in the tables, are sufficient for communicating my findings. Figures 28-31 are included to provide a visual of the data and mapping processes behind these statistics.

Analysis of host community per capita income (U.S. dollars) in Region 5's NPL site hotspot:

The Greater Minneapolis Area

Figure 28

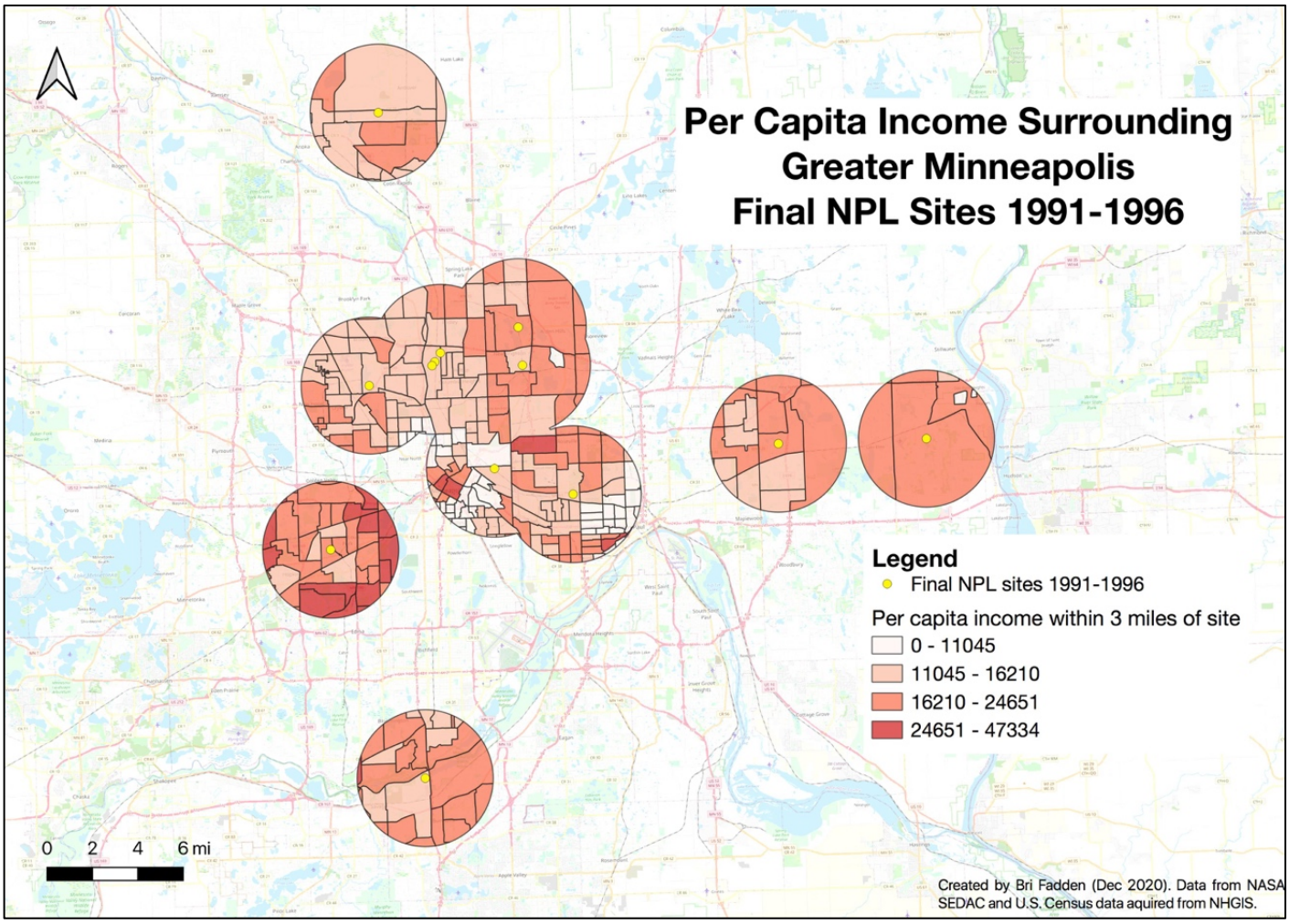


Figure 29

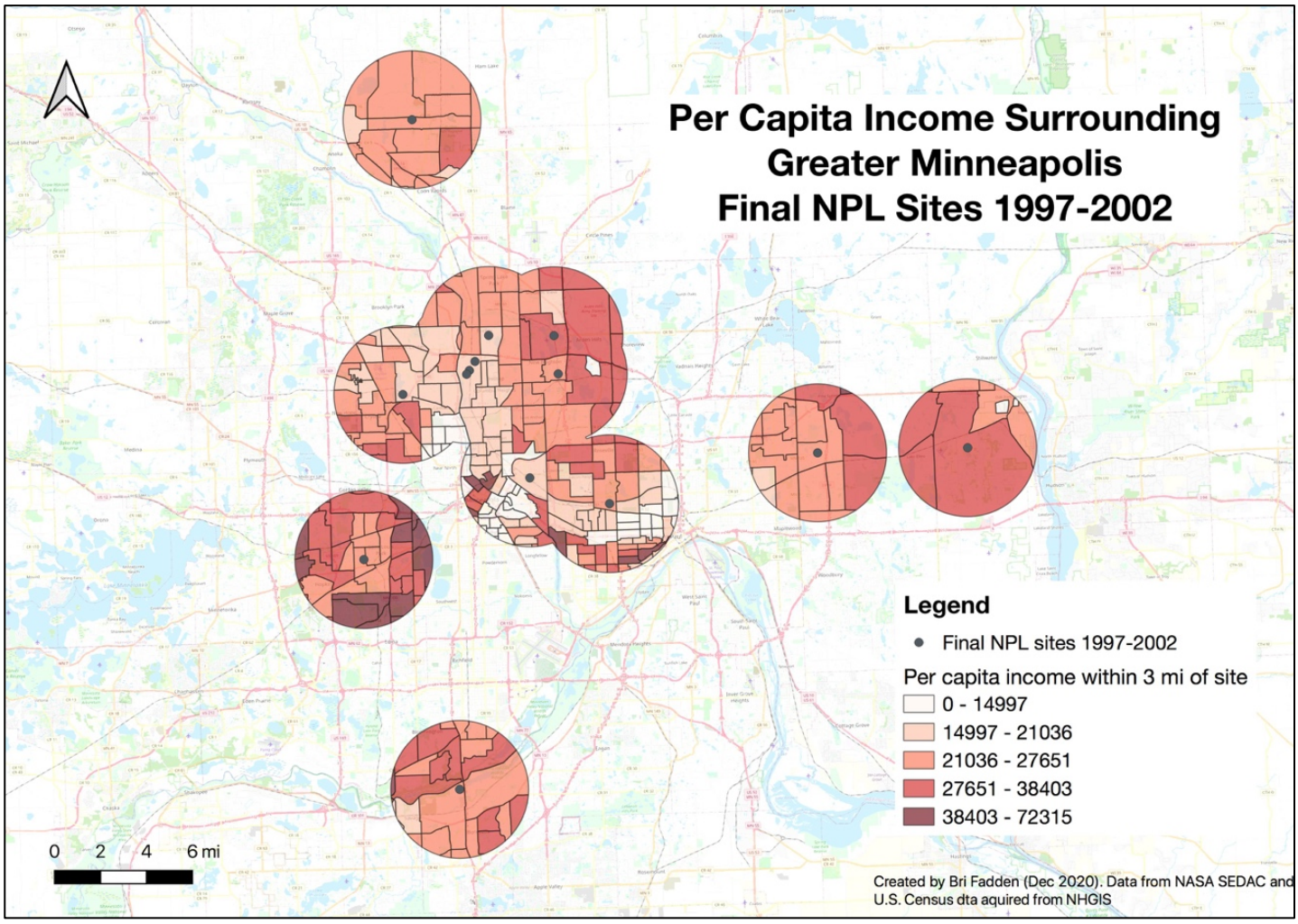

Per Capita Income Surrounding
Greater Minneapolis
Final NPL Sites 1997-2002
Legend
Final NPL sites 1997-2002
Per capita income within 3 mi of site
0 - 14997
14997 - 21036
21036 - 27651
27651 - 38403
38403 - 72315
0 2 4 6 mi
Created by Bri Fadden (Dec 2020). Data from NASA SEDAC and
U.S. Census dta aquired from NHGIS

Figure 30

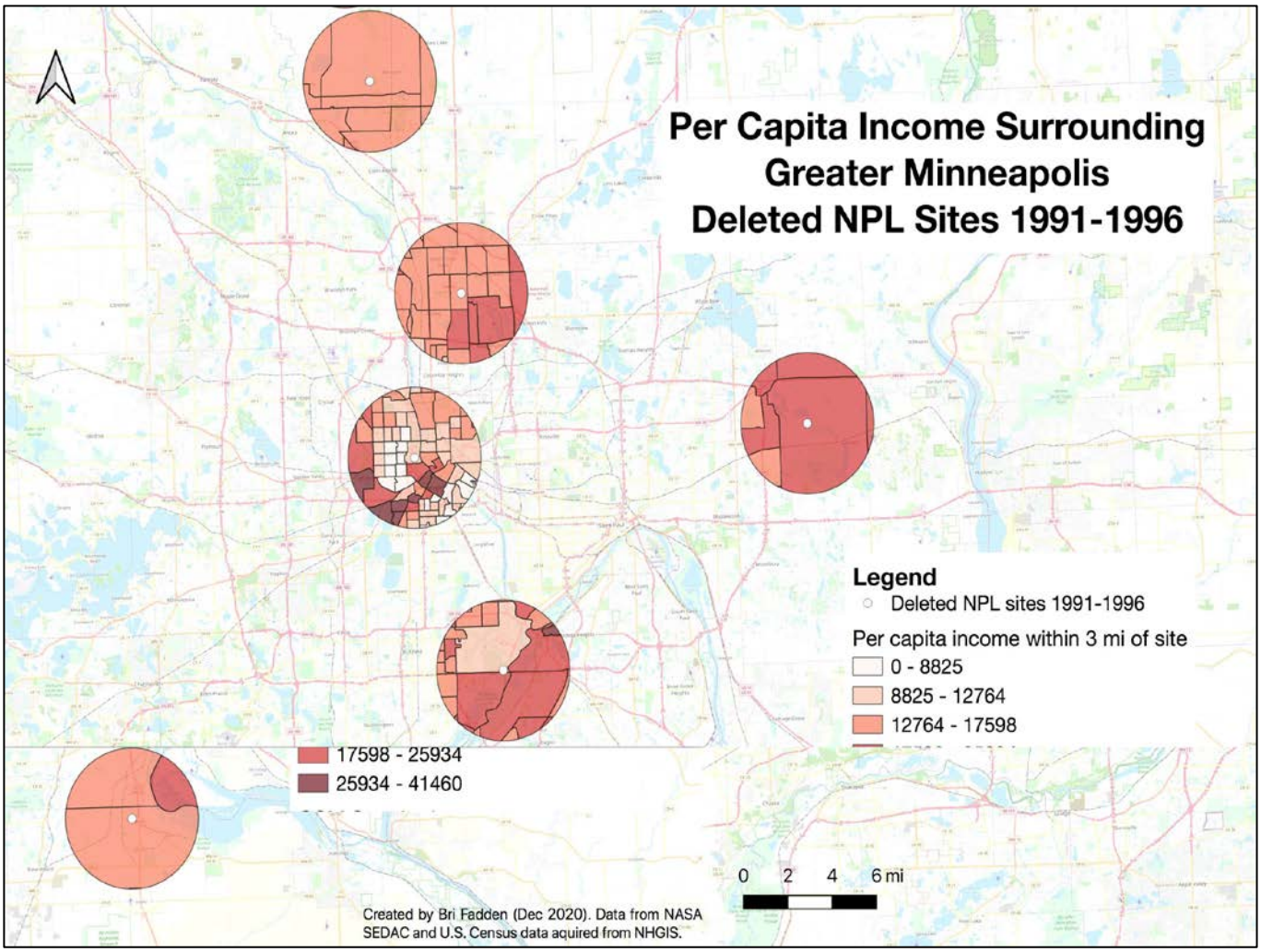
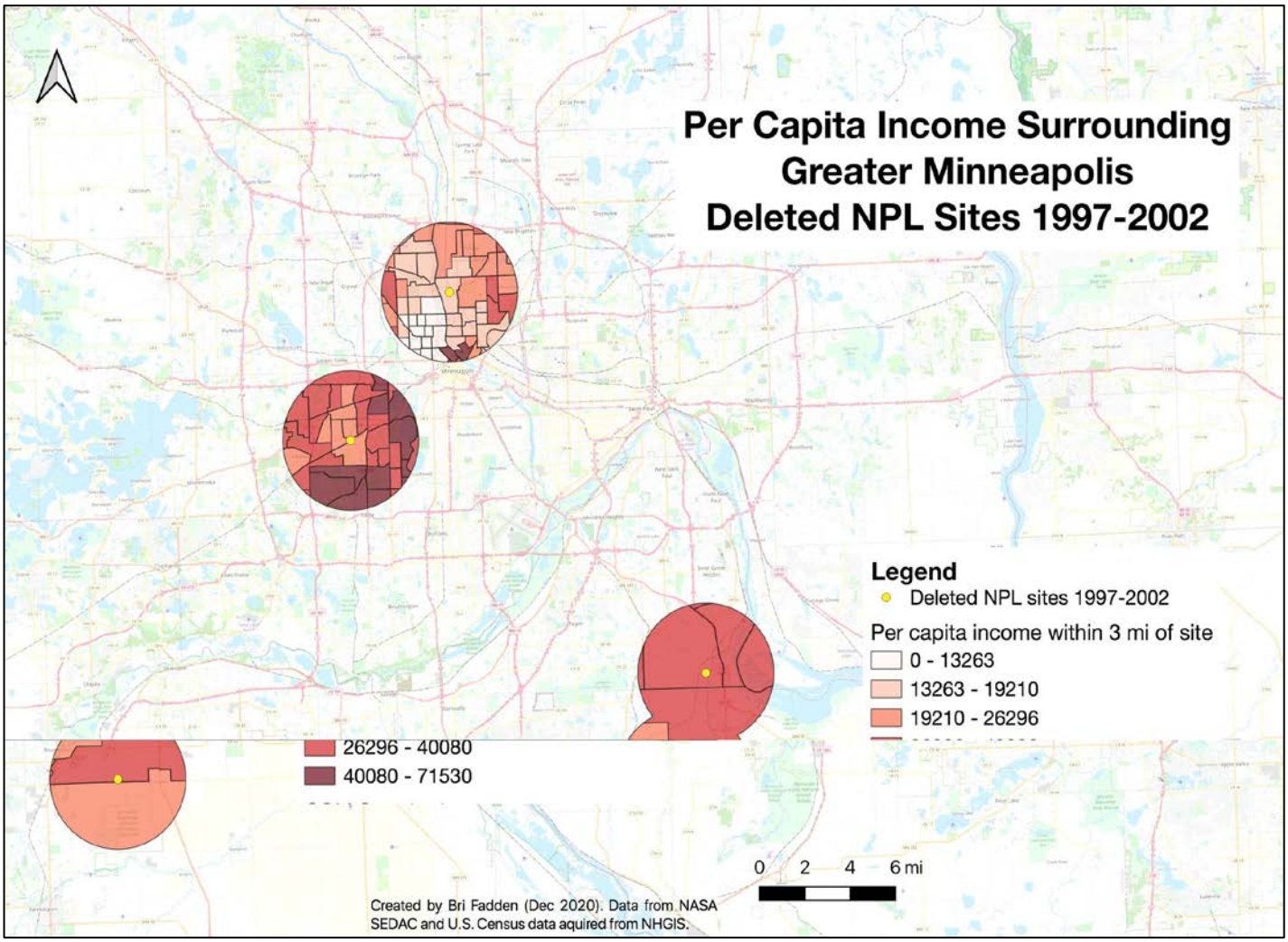

Per Capita Income Surrounding
Greater Minneapolis
Deleted NPL Sites 1991-1996
Legend
Deleted NPL sites 1991-1996
Per capita income within 3 mi of site
0 - 8825
8825 - 12764
12764 - 17598
17598 - 25934
25934 - 41460
0 2 4 6 mi
Created by Bri Fadden (Dec 2020). Data from NASA SEDAC and U.S. Census data aquired from NHGIS.

Figure 31



Racial and ethnic demographics of census tracts within 3-miles of NPL sites

Existing scholarship has shown racial and ethnic demographics of communities surrounding Superfund sites are mainly nonwhite and Hispanic, however, this can vary by the region and time period of study. In my analysis, I assessed how these racial and ethnic distributions connect to sites cleaned up during and after the SARA taxes. Here, I discuss findings on the average percent white, percent nonwhite, and percent Hispanic, which have

been calculated by census tract, of NPL site host communities in EPA Region 5 from 1991-2002.

Average percent white of NPL host community

Figure 32

percent white	
final NPL sites	avg. within 3 mi buffers
1991-1996	49.97%
1997-2002	45.99%
deleted NPL sites	avg. within 3 mi buffers
1991-1996	47.56%
1997-2002	36.62%

Figure 33

Difference in avg. across SARA expiration threshold	
final NPL sites difference	-3.98%
deleted NPL sites difference	-10.94%
difference between final & del.	-6.96%

As seen in Figures 32 and 33, there was not a substantial difference between deleted NPL sites and final NPL sites across the SARA tax expiration threshold, especially considering that overall, in EPA Region 5, from 1990 to 2000 there was a decrease among the census tracts average percent white by 4.6%. When put in context with the change between final and deleted sites from during the taxes to after, this makes the -6.96% change even less consequential. As a result, it can be inferred that sites were not chosen for cleanup based on the whiteness of the NPL site host community after the SARA taxes expiration.

Average percent nonwhite of NPL host community

Figure 34

percent nonwhite	
final NPL sites	avg. within 3 mi buffers
1991-1996	9%
1997-2002	10.80%
deleted NPL sites	avg. within 3 mi buffers
1991-1996	11.55%
1997-2002	23.35%

Figure 35

Difference in avg. across SARA expiration threshold	
final NPL sites difference	1.80%
deleted NPL sites difference	11.80%
difference between final & del.	10.00%

Here, a relatively significant change in the average percent of nonwhite people surrounding deleted NPL sites while the SARA taxes were in effect compared to after their expiration occurred. This is demonstrated by the 11.8% increase in the average percent of nonwhite people living within 3 miles of deleted sites from 1991-1996 compared to 1997-2002. Thus, from 1997-2002, sites with higher percentages of nonwhite people were actually remediated more than those with less nonwhite people. This difference carries weight as there was only a 2.12% increase in the average percent of the nonwhite population by census tract in Region 5 as a whole from 1990 Decennial Census to the 2000 Decennial Census.

Average percent Hispanic of NPL host community

Figure 36

percent Hispanic	
final NPL sites	avg within 3 mi buffers
1991-1996	1.75%
1997-2002	3.50%
deleted NPL sites	avg within 3 mi buffers
1991-1996	1.40%
1997-2002	4.10%

Figure 37

Difference in avg. across SARA expiration threshold	
final NPL sites difference	1.75%
deleted NPL sites difference	2.70%
difference between final & del.	0.95%

The average percent of Hispanic peoples living within 3 miles of deleted NPL sites during the SARA taxes compared to after they expired did not significantly change (Figure 36). The minuscule difference between final and deleted sites as seen in Figure 37 indicates that the percentage of the host community identifying as Hispanic did not play a role in whether or not a site was remediated after the SARA expiration. Thus, while those who are Hispanic are often more likely to live in close proximity to Superfund sites, here, in EPA Region 5 from 1991-2002, this indicator did not play a role in influencing if a site was remediated or not (UCC 1987).

Discussion: spatial analysis of NPL site host community demographics

Overall, my spatial analysis findings did not indicate a strong relationship between the SARA taxes' expiration and the shift in community demographics including average percent

white, nonwhite, Hispanic, and average per capita income. Yet, among these indicators, the only relatively significant change in community composition around deleted NPL sites across the SARA expiration threshold occurred among the average percent nonwhite. This is seen in the 11.8% increase in the average percent of nonwhite people living within 3 miles of deleted sites from 1991-1996 compared to 1997-2002. While this finding appears to be tied to SARA on the surface, it is crucial to contextualize this shift within other external factors that could have influenced this outcome.

A key factor likely contributing to this increase of remediated sites with nonwhite communities is president Clinton's Executive Order 12898: "Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations" issued on February 11, 1994 which stated:

> "…each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions" (Clinton 1994).

This executive order called for the EPA to implement an environmental justice strategy, promote nondiscrimination in their programs such as the Superfund, and offer minority and low-income communities equitable access to information and participation (Clinton 1994). Yet, there has been limited research on the implementation and subsequent effect of Superfund reform bill E.O. 12898 on Superfund remediation. Rather, studies have mainly focused on the relationship between community demographics and NPL listing rather than a site's likelihood for cleanup (O'Neil 2007). Similarly, there have only been national-level studies on the executive order, leaving regional implementation of environmental justice strategies largely unknown (O'Neil 2007). While it is possible that regional managers in EPA Region 5

deliberately remediated sites based off of environmental justice considerations, there was only an approximate 10% increase in the percent nonwhite surrounding deleted sites after SARA's expiration. Yet, it is still important to note that this 10% increase may hold more weight given the relatively low proportion of nonwhite people living in Region 5 census tracts as a whole (under 20%) as seen in Figure 21.

Given the potential effect of E.O. 12898 on my spatial analysis findings in addition to the mainly insignificant shifts in host community demographics around remediated sites during and post-SARA, it can be concluded that the taxes themselves did not have a direct effect on the types of communities prioritized for cleanup in EPA Region 5. These findings offer crucial insight into how funding connects to environmental justice implications at Superfund sites as it helps answer the question: who benefits from the Superfund remediation program? If predominantly white and higher-income communities were being deliberately favored when funding for the Superfund program was low (such as post-SARA taxes), there would be serious consequences not only for the program itself but also for the underserved communities in need of site cleanup action. From my spatial analysis study, it is clear the SARA taxes did not in fact have this effect but were rather inconsequential to which communities received remediation at their NPL sites. However, the SARA taxes were implemented on a national level and could have impacted the other EPA Regions differently. While Region 5 completed the most remediations of all regions during this period, it still cannot necessarily speak for the program's response to limited funds as a whole.

Policy Implications and Recommendations

Determining whether the SARA taxes should be reinstated ultimately comes down to the overarching issue of how Superfund's funding resources impact its ability to remediate hazardous waste sites. Findings demonstrate that cost considerations of NPL sites were likely driving regional remediation decisions in EPA Region 5 after the SARA tax expiration. This prioritization forgoes the Superfund's intended goal to remediate the *most* hazardous waste sites in the country, not just the ones that do not entail steep costs or have able PRPs. With this trend in motion, sites in the direst need of cleanup might be overlooked or deliberately avoided solely due to fiscal barriers. This has serious implications for communities living in close proximity to sites. Given that remediation processes can take multiple years (several years for "megasites"), putting off cleanup action can allow contaminants at a site to potentially exist for generations (Schmidt 2003). Living with toxicity often represents a form of "slow violence" where "long-term exposure, in which toxicants accrete into the body, cause slow deaths, mutations and disease" (Stewart 2017). This speaks to the "time depth and intergeneration temporality" of toxins as many can have long biological half-lives such as lead which takes 40 years to only partially dissipate from the body (Stewart 2017). Additionally, the presence of toxins within human bodies and the natural world can create ongoing cycles of harm in which human and nonhuman systems are in constant exposure to damaging contaminants (Stewart 2017). This threat to human and environmental health highlights why the implementation of the Superfund program is so important. It is crucial that the most dangerous sites are addressed first and with utmost priority. Yet, as presented in my findings, the program appears to have remediated sites associated with less costs after SARA expired. Remedying this issue within Region 5 is difficult as the Superfund program, while implemented on this regional level, is guided by

national level policy. Thus, the other EPA Regions must be compared to one another and assessed as a whole in order for the efficacy of the SARA taxes to be truly understood. It is inappropriate to assume that the same trends in Region 5 have occurred nationwide.

Despite the scope of my research, it is also important to note how my findings align with narratives presented in scholarship expressing the Superfund's cherry picking of relatively quick, easy, and cheap sites to remediate, especially when trust fund balances are low (Schmidt 2003). Other reports have found that since the SARA taxes have expired, remediation at multiple sites were set back due to insufficient funding (CRS 2008). For example, according to an EPA report, in fiscal year 2003, the remedial action program fell $175 million short of EPA regional funding needs (CRS 2008). Additionally, in fiscal year 2004, the EPA expressed to the House and the Senate that it was unable to carry out remediation construction at 19 sites solely due to a lack of adequate funding (CRS 2008). If the costs of NPL Superfund sites were the main determinant of whether sites receive remediation attention post-SARA, it could be argued that the SARA taxes should be reinstated to ensure the Superfund program can carry out its intended goals without the prioritization of financial implications.

Reinstating the SARA taxes could serve as an effective way to raise billions of dollars for cleanups that have yet to be matched by general fund revenues supported by taxpayer dollars (GAO 2003). The taxes' reinstatement could be especially vital as the number of megasites on the NPL have been growing over time and will ultimately cost the Superfund billions of dollars to remediate (Probst et al. 2001; Schmidt 2003). It appears taxpayer dollars may be insufficient for the complicated and costly sites that are to come. While my research on EPA Region 5 helps to bridge the gap between EPA funding and its on-the-ground implementation of the Superfund remediation program, it is still unclear if the reintroduction of

the SARA taxes would solve the lull in site cleanups at Superfund sites. Studying the Superfund is notoriously difficult as connecting one of the program's inputs (such as funding) to an output (such as a deleted fully remediated NPL site) involves accounting for the remediation system's many moving parts and processes. With this lack of a clear relationship between inputs and outputs, reinstating the SARA taxes has faced stark opposition.

Republican opposition to the SARA taxes can be seen in their failed reinstatement in the Clinton and Bush administrations as well as a more recent attempt in the 116th Congress when a revised taxation bill ultimately died in the Senate's Committee on Finance (Booker 2020). This bill, S.3157 "Superfund Polluter Pays Restoration Act of 2020," sponsored by Senator Cory Booker, proposed an amended reinstatement of the SARA taxes to help fund the Superfund program. Specifically, the bill called for an increase in the tax per barrel of crude oil from 9.7 cents to 16.3 while adjusting for inflation after 2019, an increase in the tax of an updated toxic chemicals list while adjusting for inflation, and a reestablishment of the corporate environment income tax to 0.12 percent of revenue in excess of $3,735,000 (Booker 2020). The bill also outlined an update for the term 'crude oil' to include "crude oil condensates, natural gasoline, any bitumen or bituminous mixture, any oil derived from a bitumen or bituminous mixture (including oil derived from tar sands), and any oil derived from kerogen-bearing sources (including oil derived from oil shale)" expanding the type of oil that can be taxed to ultimately raise more revenues (Booker 2020). Additionally, bill S.3157 intended to enable the revenues raised by the taxes to be directly accessible to the Superfund program instead of depending on Congress to appropriate funding from general revenues (Booker 2020). The failure of this bill to get a vote speaks to the ongoing debate regarding the efficacy of the SARA taxes and their importance to the Superfund program's funding needs. More robust and conclusive research on

the taxes is needed if their reinstatement is going to earn majority support in Congress. While it has been made clear by the EPA that the Superfund needs are outgrowing its funding resources, there has not as of yet been a solution to this worsening issue. Thus, the most "effective" remedy cannot be determined until the policy research pertaining to Superfund implementation of remedial actions is explored in further depth.

Conclusion

In my thesis, I set out to assess the impact of the SARA taxes on NPL site remediation results in EPA Region 5 by comparing final and deleted NPL sites across the tax expiration threshold. Through my mixed-methods approach of site-specific attribute analysis including the distributions of site categories, overall action leads, stakeholder remedial design/action leads, and community involvement and comparative spatial analysis of host community demographics, I gained deeper insight into the efficacy of the taxes. Specifically, my findings identified shifts in site category and stakeholder remedial design and action leads enabling me to connect the Superfund's funding resources to on-the-ground remediation decisions and outcomes. My analysis uncovered the potential prioritization of cheaper, less complicated sites, as well as sites with present and able PRPs after the SARA taxes expired in 1995. These findings were expected as the Superfund's trust fund balance significantly decreased after 1996 making it more difficult to take on costly sites that are typically more hazardous (GAO 2003). If the Superfund cannot carry out its intended goal to remediation the most hazardous waste sites in the country due to funding limitations, the program risks neglecting dangerous uncontrolled contaminants at certain sites. This has long-term implications for human and environmental health as the leaching of

hazardous waste into the soil and groundwater, for example, can create intergenerational communities of harm and toxicity (Stewart 2017).

As discussed throughout my research, this study was limited by the small sample size of deleted sites in EPA Region 5 (54 in total) making it inappropriate to put substantial weight on the significance of my research results. Whether the SARA taxes should be reinstated remains unclear as national level research is needed to gain a more conclusive and holistic understanding of their impact on Superfund's remediation decision-making. Despite this, my study sets the stage for additional research on the SARA taxes both at a regional and national level as, prior to this report, the taxes' impact on NPL remediation results had yet to be explored. With a more complete understanding of the taxes, policymakers and EPA agency leaders can identify if this mode of revenue collection results in improved Superfund remediation outcomes.

Successful implementation of the Superfund program is essential to keeping at pace with the constant addition of hazardous waste sites, especially megasites (sites averaging $140 million in cleanups) (Schmidt 2003). While Superfund has made substantial progress over the years through its remediation program, its funding dilemma speaks to the larger issue of continued improper waste disposal and the ever-increasing byproducts of industrial processes and systems nationwide. Given that the Superfund only retroactively addresses uncontrolled hazardous waste rather than stopping contamination of the environment before it starts, the program can only cleanup after damage to human health and the natural world has already been done. Although the Superfund program may need to rethink its funding mechanisms and remediation priorities, stricter waste management laws and protocols may be more effective in breaking this endless cycle of toxicity and cleanup.

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