Maine's Brownfields:
The Costs and Contexts of Rural and Urban Brownfields Redevelopment

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ABSTRACT

Maine's rural communities have a proud legacy of manufacturing mainstays such as lumber, paper, and textile mills. While these industries were foundational to the state's economy, the closure of many of these businesses has left several of Maine's towns burdened with degrading industrial infrastructure in addition to the loss of their economic base. This paper explores how these communities have approached assessment, remediation and redevelopment utilizing funds from federal and state Brownfields programs. Leveraging data from EPA's Clean-ups in my Community (CIMC) database and the database of remediated sites from the Maine Department of Environmental Protection, we will compare the site and grant profiles of Maine's urban and rural brownfields to determine the unique challenges faced by rural communities on the path to revitalization and redevelopment.

INTRODUCTION

From paper and textile mills to the lobster fishery, Mainers have always had a knack for turning rich natural resources into an industrial base capable of sustaining their communities (Segal 2014). As closure and abandonment hit these former keystone businesses, however, the communities they served have been left with adverse environmental and economic consequences. Releases of harmful pollutants from some of these businesses, such as the former Holtrachem plant in Orrington, continue to affect aquatic and terrestrial ecosystems and human health (Rudd et al. 2018). Furthermore, the recent closure of paper mills between 2011 and 2016 led to a subsequent decrease in forest product employment by an estimated 13.5 percent (Crandall et al. 2017)

The US Environmental Protection Agency (EPA) facilitates environmental remediation for the most severely contaminated properties in the nation through programs such as that created by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or Superfund,[1] but many smaller properties with less severe contamination are left to state and local entities with the aid of federal and state funding. These sites are defined by the US EPA (2020a: 64) as brownfields, or "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant." Although their revitalization and redevelopment can be complicated from a planning and governance perspective, brownfields offer a unique development opportunity for states and municipalities to spur economic growth and address public health concerns (De Sousa et al. 2023).

Brownfields redevelopment has been shown to provide socioeconomic and health benefits to communities. Most economic scholarship has focused on the impact of nearby housing prices using hedonic studies of housing sales prior to, during, and after redevelopment. The most comprehensive of these studies found that the redevelopment of brownfields increases housing sale price by 5 percent to 11.5 percent (Haninger et al. 2017). From a public health perspective, the remediation of brownfields decreases the risk of contamination and hazardous material exposure, which can lead to better health outcomes, decreased medical expenditures, and improved quality of life (De Sousa et al. 2023).

Most, if not all, examinations of the challenges and opportunities provided by brownfield redevelopment in the United States focus on the urban environment, while studies focusing on understanding how the process unfolds in rural communities have been limited (De Sousa et al. 2023). While there is also a wealth of research considering the distributional equity of revitalization's benefits, very little considers the disparities between urban and rural contexts (Kiessling and Maxwell 2021). To begin addressing this knowledge gap, we investigate the differences between urban and rural brownfield projects in Maine, specifically examining cleanup costs, leveraged funding sources, and process and time for redevelopment.

Brownfields Overview

Brownfield redevelopment mainly involves three consecutive steps: assessment, cleanup with monitoring, and redevelopment (De Sousa 2021). The environmental site assessment typically includes two separate phases, though supplemental assessment may be necessary depending on site conditions. Phase I environmental assessments are conducted to review previous records and identify areas of recognized environmental condition (RECs) to determine the presence or the likely presence of contamination in the property. A Phase II assessment may follow with environmental testing of various media such as soil and groundwater. A hazardous building materials assessment may also be conducted for the testing of hazardous substances in buildings such as lead and asbestos.

After the assessment is completed, a remediation plan is crafted that includes a risk-based approach to manage or eliminate the contamination in the property. For example, if a property's soil and groundwater are found to be contaminated, affected soils may be capped to prevent the spread of contamination or may be disposed off-site. In many cases, the contamination that is left on property can restrict the types of future site use to limit accidental exposure or destruction of the cap. These physical barriers and regulatory restrictions are referred to as engineering controls and institutional controls, respectively, and they are integral to post-clean up redevelopment planning (De Sousa 2021)

As the primary funder of assessments and cleanups, EPA provides millions in grant funding to state and local programs as well as nonprofit organizations every year (De Sousa 2021). These funds were originally authorized by the CERCLA in 1980 to provide resources for addressing smaller-scale contamination. In the initial stages of the program, strict liability definitions outlined in the statutes disproportionately left many smaller businesses unable to cover the cost of cleanup, as they could be found responsible for legacy contamination in addition to their own. After extensive research efforts by the EPA, as well as advocacy by community activists and state and local governments, Congress created a more robust funding structure that eased some of the liability language with the Small Business Liability Relief and Brownfields Revitalization Act of 2002. These statutes were outfitted with even more funding, liability relaxation, and the expansion of technical assistance by the 2018 Brownfields Utilization, Investment, and Local Development (BUILD) Act (US EPA 2018).

EPA's current funding structure is divided between competitive grants for communities and regional nongovernmental organizations, noncompetitive grants for states and tribes, and revolving loan fund establishment grants.[2] Competitive grants for individual property assessment and clean up are the most commonly awarded, but multipurpose grants and community-wide assessment grants for municipalities and regional groups are also available. The state and tribal noncompetitive grants, also known as Section 128a grants after CERCLA section 128a, apportion funds to states and federally recognized tribes to supplement local efforts in assessing and cleaning up brownfields, as well as facilitating statewide inventories of current and potential sites (US EPA 2022a). Finally, competitive revolving loan fund grants allow county or local governments and nongovernmental organizations to create revolving loan funds to assist small businesses and other entities in performing assessments or clean-ups within their jurisdictions (US EPA 2022b).

In addition to EPA funding, grant recipients are encouraged to seek other financial support for the property redevelopment by leveraging their EPA funding as proof of a worthwhile investment (US EPA 2016). A critical component in evaluating the financial viability of a brownfield project is the formulation of a capital portfolio that incorporates diverse financial resources necessary to support project completion. Additional funding often comes from other federal agency grants, as well as from state, private, and foundation support. For example, the US Department of Housing and Urban Development and the Economic Development Administration of the Department of Commerce provide funds for economic and residential development, which are often the anticipated reuse of brownfield properties. Furthermore, local and commercial banks may be more amenable to provide low-interest financing for developers and businesses involved in a brownfields redevelopment if the EPA has already invested in the project.

Brownfields in Maine

The Maine Department of Environmental Protection (DEP) oversees the administration and inventorying of Maine's brownfields and has done so for over three decades. In 1993, the legislature took steps to address contaminated land by establishing one of the first Voluntary Response Action (VRAP) programs in the country, which granted Maine DEP the authority to oversee voluntary environmental assessments and abatement procedures by businesses and other organizations in seeking to avoid future enforcement actions (Maine DEP 2018a). This program, which continues to function in tandem with the official brownfields office, was recognized as an innovative standard for other states in dealing with contaminated properties (Taylor et al. 2010).

In 1995, Maine DEP received its first section 128a grant and established a formal brownfields program within the Bureau of Remediation and Waste Management to facilitate timely and effective remediation (Maine DEP 2018b). In addition to providing funds for assessment and cleanups, the program maintains a statewide inventory of current and formerly contaminated sites, and monitors whether sites have effective institutional or engineering controls. The divisions of oil and hazardous waste facilities regulation contribute to the program by enforcing response actions to the appropriate remedial standards, and the VRAP program infrastructure facilitates the approval of clean-up plans and certifies completion. Finally, the brownfields program offers pathways for public communication and participation by allowing community members to initiate entries into the inventory, check property status, and communicate all updates to sites monitored through the inventory.

Local and regional brownfields programs are coordinated by county and municipal governments that are primarily funded by competitive grants and revolving loan funds. For example, the cities of Portland, Lewiston, and Bangor have received millions in EPA funding to use for large- and small-scale redevelopments. Maine's regional economic development districts, such as the Eastern Maine Development Corporation and the Androscoggin Valley Council of Governments, also run brownfields programs using EPA funding through their regional planning divisions and assist small businesses and municipalities in conducting assessments and cleanups. Maine's nonprofit organizations also maintain brownfields programs for specialized and general projects. For example, as we explore later in our discussion, the community development group Our Katahdin has secured several million dollars in EPA funding to help redevelop brownfields sites across in Millinocket, while the Children's Museum & Theatre of Maine in Portland has also secured EPA and leveraged funding to redevelop Thompson's point.[3]

Despite the substantial and multilevel collaborative effort to redevelop Maine's brownfields and the availability of existing data, there has been no comprehensive and systematic review of the program. Specifically, there is little official documentation on the duration and cost of the average redevelopment, and there have been no formal analyses to identify the factors affecting those costs across urban and rural contexts. This article begins this process using publicly available data from EPA's database to compare assessment and cleanup costs, rates of successful redevelopment, including site former uses and types of contamination present. Our results highlight the need for additional analysis of the implications and economic impact of brownfields redevelopment in Maine. Our results underscore the importance of developing a brownfields impact assessment initiative that would support the mission of Maine's brownfields program and inform practitioners and stakeholders about the benefits and challenges to redevelopment.

DATA SOURCES

To assess the difference between urban and rural brownfields, we used data from the Assessment, Cleanup and Redevelopment Exchange System (ACRES) database, which is the grant reporting repository used by the EPA's Office of Brownfields and Land Revitalization (OBLR) to track brownfields grants. The database provides a wealth of information on properties that have received funding by the EPA, including assessment and cleanup activities, the amount of funding per activity, dates of activities, property descriptions, and whether properties are ready for their anticipated reuse. While the data is publicly available via the EPA's Cleanups in my Community tool,[4] we received a bulk download from OBLR on June 20, 2024. The resulting dataset included information for all 844 properties in Maine that received EPA grants from September 1996 to August 2023. It should be noted that the dataset includes only the properties that have received EPA funding, but additional brownfield sites that are not represented in this dataset may exist within the state.

The ACRES data was appended using three additional data sources. Properties were first geocoded according to their latitude and longitude to be classified as rural or urban based on their location relative to urban area boundaries as delineated by the US Census Bureau after the 2020 decennial census.[5] While this does not account for brownfields' role in the changing urbanicity of Maine's communities, it provides a useful starting point to understand how properties are situated amongst the present population.

Based on the property descriptions in ACRES database, we classified the properties' former uses using the 2022 North American Industry Classification System[6] (NAICS) codes. The NAICS system groups industries into multiple levels of organization based on the number of digits in the classification. We use the following levels to classify former uses: two-digit sectors, three-digit subsectors, and six-digit industries. In cases where the former use or property highlights fields were not available, we consulted press releases, google maps, or Phase I assessments. We also created a new industry classification to supplement the NAICS codes, "90—Undeveloped Land and Single/Multifamily Housing," for former uses that are not classifiable as an industry. If a property was a residential house that was used for single or multifamily occupancy, we classified it as "90000—Residential Property." If a property had no previous development, as is the case for many properties that may be adjacent to other sites, we classified the former use as "90001—Undeveloped Land." Finally, if we could not find any information that indicated previous use or the former use was a roadway, we classified the property as "90002—Unknown former use," or "90003—Roads," respectively.

Finally, we adjusted all reported funding for inflation using the Producer Price Index for all commodities based on the grant award date.[7] While a specialized index for the environmental consulting services (54–Professional, Scientific, and Technical Services) would more accurately reflect spending for assessment and remediation activities, this deflator is only available from 2009 onwards. As Maine's first federal grants date back to the 1990s, we used the index for all commodities to account for continuity and consistency. Funding totals are presented in May 2025 real USD in the main text, and in nominal and real amounts in our supplemental materials.

RESULTS

From the 844 properties included in EPA funded brownfields database for Maine, 383 were classified as rural while 461 fell inside of a Census-designated urban area. Our results highlight several key differences between urban and rural brownfields. A significant finding of this study is that rural brownfields tend to receive substantially less funding on average from the EPA and other sources compared to urban brownfields, and this funding tends to come from state and county governments. Despite this, a higher proportion of rural brownfields are ready for their anticipated reuse, and their remediation takes a shorter amount of time than their urban counterparts on average. We also find moderately different former use frequencies between urban and rural brownfields, with contamination mixes of inorganic (such as metals) pollutants, organic compounds, and hazardous building materials.

Former Uses

We identified 287 unique industry former uses across all 837 properties while 11 properties were unidentifiable. The three most common former industries across the whole state are general automotive repair facilities (80 properties), broadwoven fabric mills (72 properties), and gasoline stations with convenience stores (72 properties). These are typical former industrial and commercial uses for brownfield sites, as they are associated with the generation of contamination in soil and groundwater, while building materials of former mills may contain hazardous substances.

Our results indicate notable differences in proportional frequency across the urban/rural divide. The largest former use sector(s) for urban and rural brownfields is manufacturing (NAICS 31–33) at 203 and 127 properties, respectively. The results are shown in Table 1. In proportional terms, the rate of former manufacturing subsectors relative to the total number of properties differs by 2 percentage points or less across the urban/rural divide, with the exception of textile mills (13 percent urban, 4 percent rural, 9 pp difference) and food manufacturing (1 percent urban, 4 percent rural, 3 pp difference). The other services (NAICS 81) and retail trade (NAICS 44–45) sectors are the second and third most identified former use among urban and brownfields, though in reverse order. In total, 73 rural properties (82 urban) were formerly used for retail trade while 67 (103) had been used for other services. A full breakdown of these results is shown in our supplemental materials.

The five most common six-digit NAICS industries across the urban rural divide are given in Table 1. The most common industries associated with rural brownfields are gasoline stations and general automotive repair, while the most common for urban brownfields is broadwoven fabric mills. This finding is, to some extent, anticipated as mills often trace their origins of industrial development in the mid-19th century, where their central location close to railroads facilitated the transportation of goods and supported the growth of surrounding

TABLE 1: **Five Most Common Former Uses of Brownfields**

Location	Properties (% of total)	Sector	6-digit NAICS	Industry description
Rural	44 (11.5)	45–retail trade	457110	Gasoline stations with convenience stores
	40 (10.4)	81–other services	811111	General automotive repair
	31 (8.1)	61–educational services	611110	Elementary and secondary schools
	23 (6.0)	90–undeveloped land & single/multifamily housing	900001	Undeveloped land
	21 (5.5)		900000	Residential property
Urban	55 (11.9)	31–manufacturing	313210	Broadwoven fabric mills
	40 (8.7)	81–other services	811111	General automotive repair
	39 (8.5)	53–real estate rental & leasing	531110	Lessors of residential buildings and dwellings
	37 (8.0)		531120	Lessors of nonresidential buildings (except mini warehouses)
	33 (7.2)	61–educational services	611110	Elementary and secondary schools

neighborhoods. Many rural brownfields contain some amount of notably undeveloped land, which may result in lower redevelopment costs and faster redevelopment, showcasing similarities with greenfields, especially if the former uses occurred in a small part of the overall property. Schools were also found as one of the most common former uses in both rural (~8 percent) and urban areas (~7 percent), as the presence of hazardous building materials and underground storage tanks often increase the likelihood of exposure to contamination. There are also several instances of residential properties categorized as brownfields in urban areas, which is not a typical former use for brownfields. These properties may be targeted for redevelopment due to potential contamination from hazardous building materials or to their strategic location within larger area-wide revitalization plans.

Contamination Profiles

Urban and rural brownfields share their five most common contaminants, but there are differences in proportional frequencies as shown in Table 2. Lead and asbestos are the two most frequent contaminants at urban brownfields, while rural properties are mostly contaminated by petroleum, though asbestos and lead are highly frequent types of contamination. These differences are associated with the former uses of the properties. Given that mills and commercial or apartment buildings are among the most common former uses at urban brownfields, lead and asbestos are likely to be present. For rural areas, automotive related industries are the most common, and hence, petroleum products are common contaminants in soil and groundwater. Furthermore, many old schools, which are common former uses for both urban and rural properties, may contain asbestos tiles, further contributing to its abundance. To a lesser extent, both types of properties are contaminated with polycyclic aromatic hydrocarbons, which are often related to combustion-related activities such as coal gas plants and tar production.[8] The final most abundant contaminant falls under other metals; EPA requires the reporting of the Resource Conservation and Recovery Act's eight toxic metals[9] (e.g. arsenic, cadmium, and mercury) that often occur during industrial processes, while the category other metals is used to capture those more niche in industrial production, such as cobalt and antimony.

The proportional differences in detection frequencies, relative to total properties, of lesser common contaminants all come in at under 3.5 percentage points except for arsenic. Though it is not among the most common contaminants at either urban or rural brownfields, it is found almost twice as often at urban ones (15 percent urban vs 7.5 percent rural). Urban fill is the most likely source of the metal contamination, particularly for arsenic. Contaminated fill material, often consisting of demolition debris, coal ash, and other industrial byproducts, was used in the development of many urban areas. This finding also corroborates research from the early 2000s, which found that urban areas experience arsenic exposure through the air and contaminated soils at greater rates than rural areas, except in areas adjacent to agricultural pesticide applications (Chirenje et al. 2003).

TABLE 2: **Frequencies of the Five Most Detected Contaminants in Maine's Brownfields**

Contaminant	Rural properties N	Rural properties % of total	Urban properties N	Urban properties % of total
Asbestos	114	29.8	171	37.1
Lead	111	29.0	174	37.7
Other metals	70	18.3	97	21.0
Polycyclic aromatic hydrocarbons	82	21.4	115	24.9
Petroleum products	122	31.9	130	28.2

Funding and Redevelopment Time

Our analysis highlights differences between rural and urban areas both in rate and duration of brownfield redevelopment. As shown in Table 3, 42 percent of rural properties have been fully remediated and redeveloped, compared to 27 percent of urban properties. The redevelopment takes an average of three years and four months for rural areas, while their urban counterparts tend to take an additional two years. The differences between the urban and rural brownfields are not only shown in rate and duration but also in remedial costs. Urban revitalizations were found to be more costly than those in rural areas, requiring $124,368 compared to $64,609 for rural properties. Another important finding is that proportionally fewer rural brownfields leverage their EPA funding into further private or public funds, and when they do, the average amount is one-sixth that of urban properties ($1.2 million urban vs $209,000 rural). Leveraged resources for urban brownfields are substantial, with a public to private investment ratio of approximately 1:10, demonstrating the importance of public funding to catalyze private investment, particularly in urban settings.

Over 50 percent of EPA funding for urban brownfields is granted to local governments or organizations, with the rest going to regional organizations or Maine DEP. In contrast, only 16 percent of rural brownfields funding was granted to local organizations, and the majority was granted at the county, regional, and state or tribal levels (see our supplemental materials for exact funding proportions). One reason for the discrepancy in leveraged funding could be that urban municipalities have more capacity to apply and manage these cooperative agreements, compared to rural municipalities, which often have limited resources. In both cases, local practitioners have more intimate knowledge of the brownfields they are attempting to redevelop or have a more cohesive vision for the final development. This discrepancy may also reflect their capacity to launch fundraising campaigns and attract developers, thus leverage additional funding sources. In contrast, practitioners at the regional, county, and state level are responsible for facilitating the redevelopment of many properties across diverse contexts. This may afford less bandwidth to apply to other agencies or other sources, leading to less leveraging and less funding overall per property.

We further analyzed the grant expenditures associated with assessment and cleanup activities, which are shown in Table 4. When costs are broken down by redevelopment phase, the assessment costs are similar for urban and rural sites while disparity emerges in cleanups. Phase I and II assessments cost the same on average, though urban brownfields tend to require supplemental assessments more often, and with higher cost. Rural cleanups cost an average of just over $175,000, while urban cleanups usually cost 2.25 times that amount. However, though most of the urban and rural properties report having had cleanup activities associated with them, only about a quarter of each report the actual funding amount used. This means that a large portion of cleanup funding (and some assessment funding) is unaccounted for in the federal data, which could bias our estimates if the missingness is nonrandom.

TABLE 3. **Brownfield Time to Redevelopment and Average Cost**

Location	Total properties	Redevelopment complete (%)	Mean years in redevelopment	Average reported EPA cost*	Leveraged funds* (# properties)
Rural	383	162 (42.2)	3.37	$64,609	$209,509 (96)
Urban	461	124 (26.8)	5.38	$124,368	$1,233,554 (140)

*In 05/2025 real USD

TABLE 4: **Average EPA Funding by Assessment and Cleanup Activity During the Redevelopment Phase**

Location	Assessment			Cleanup
	Phase I	Phase II	Supplemental	
Rural				
Properties (reported*)	360 (302)	321 (241)	69 (52)	309 (63)
Mean funding**	$8,708	$41,888	$14,763	$175,536
Urban				
Properties (reported*)	459 (348)	405 (274)	111 (82)	416 (102)
Mean funding**	$8,798	$43,888	$20,953	$395,205

* Number of properties used to calculate the mean, as information on the activity wasn't missing.
** In 05/2025 Real USD

DISCUSSION

Our investigation has revealed a degree of difference between urban and rural brownfields redevelopment. The differences we observe in cleanup costs and leveraged funding may be due in part to the anticipated future uses of these properties, though further research would be required to verify this statement, as reporting on future site use is scarce in ACRES. In addition to site reuse, the impact of population density on the risk of exposure may also increase reliance on engineering controls and institutional controls. Finally, the extent of contamination is likely the most important predictor of redevelopment cost, though whether this relationship is confounded by location is unclear.

To deepen our understanding of the data analysis findings, two of the most prominent case studies of brownfield redevelopment in Maine were selected for further investigation. One the most notable rural brownfields redevelopments is the former Great Northern Paper Company (GNP) mill site in the town of Millinocket. The site is currently undergoing revitalization under the efforts of Our Katadhin, a volunteer-based nonprofit organization committed to the site's redevelopment (Kleinfelder 2023). Since 2023, the site has received more than $6 million in cleanup funding from the EPA, exemplifying the catalytic role of federal funding in driving rural brownfield redevelopment. The total estimated cost for the remediation is approximately $13 million. By leveraging public-private partnerships, Our Katadhin has secured additional funding resources to complement the federal funding and complete the project. The vision for the site, known as One Katahdin Fiber Park/One North, aims to establish a hub for next-generation wood production, information technology, and industrial-scale production, alongside a planned salmon aquaculture facility that will use the site's preexisting lagoons. Upon completion, the site is projected to support the operation of 10–15 businesses, generating an estimated 300–500 new job opportunities, thereby contributing significantly to regional economic resilience and sustainable land reuse. While this example amplifies the increased cleanup costs that are often required in large-scale redevelopment, it also highlights the necessity of remedial funds for rural brownfields. When there is potential to attract private funding for the redevelopment, EPA's brownfields funds can bridge the gap of remedial costs to bring the project to completion.

In other rural areas where industrial future uses are planned, the risk of continued human exposure may be less compared to residential or commercial future uses. In these cases, the Maine DEP remedial action guidelines allow developers to rely more on comprehensive institutional controls than on more costly engineering controls (Maine DEP 2023). This would then lead to less intensive cleanup procedures, especially in places with exceptionally low population density. Lastly, municipal- or county-led rural redevelopments may seek greenspace or conservation as the intended future use, as is the case with several of the larger rural brownfield properties found in ACRES. This would inherently lead to lower risks of exposure, allowing for lower-cost green remediation measures to be used instead of high-cost manual remediation.

In contrast, urban brownfields may be more likely to seek residential or commercial reuse, as in the case of Thompson's Point, a 25-acre former industrial and railroad yard located along the Fore River in Portland. The site had a legacy of contamination from polycyclic aromatic hydrocarbons, arsenic, and petroleum-based pollutants. To support the environmental assessment and remediation efforts, ACRES indicates that EPA's brownfields program provided over $700,000 in assessment, cleanup, and revolving loan funding. The site's urban setting and complexity of the contamination contributed to elevated cleanup costs, reflecting the technical challenges of remediating soils in (densely) developed environments. Importantly, the site's proposed use as the new home of the Children's Museum and Theatre of Maine played a critical role in attracting financial support (Hoey 2019). The museum's vision and capital campaign helped leverage $15 million in investment, representing a compelling example of how targeted remediation in an urban setting can attract significant private investment when combined with cultural development goals. Today, Thompson's Point has been transformed into a vibrant cultural and recreational hub, demonstrating how federal funding together with local partnerships and private investment can catalyze urban redevelopment.

Commercial or residential reuses such as Thompson's Point will require stricter engineering controls, as the risk of exposure remains high in their absence. This is especially true in the case of lead contamination, as Maine's Lead Poisoning Control Act (MRSA Title 22 §§ 1314-1331) places strict requirements on lead remediation for residential homes and buildings. Urban mill remediations are often turned into apartments and lofts or commercial spaces like business parks or retail, as in the case of the Bates Mill in Lewiston (Valigra 2019), so more thorough abatement of indoor lead paint and asbestos is often required. The stringency of the Lead Poisoning Control Act may also explain the abundance of residential properties requiring remediation, as §1320-A. 2. enables the Maine Department of Health and Human Services (Maine DHHS) to inspect dwellings when a child is found to have lead poisoning. If lead-based building materials are found during these inspections, property owners may seek assistance from brownfields funding for further assessment and cleanup to comply with removal orders.

Our findings are further underscored by the correlation between population density as of the 2020 Decennial Census and redevelopment cost. In a post-hoc analysis, we regressed total EPA investment on population density within 500 meters of a site for all sites that are ready for their anticipated reuse. We find that a 10 percent increase in the population density surrounding a brownfields property increases the redevelopment cost by 23.3 percent (see our supplemental materials for full results and methods). We need to stress that we have not fully identified a causal model to estimate the effect of population density, as that is beyond the scope of this paper. However, as population density is a key determinate of whether a space is considered urban, the underlying association suggests that it may be a driver of redevelopment costs, making further investigation warranted.

The final, and likely largest, driver of redevelopment cost is the extent of contamination, and though not testable at this moment, it likely varies across the urban/rural divide. As shown in our results, the former fabric mills in urban locations may include more extensive contamination by asbestos, lead, and PCBs due to the size of the complexes. In contrast, the gas stations and repair garages that make up most rural brownfields are usually much smaller in terms of actual site size. If soil needs to be removed due to leaking hydrocarbons, the size and extent of plumes due to leaking under- or aboveground tanks may be less than 100 meters (Neale et al. 2002). However, data on contamination extent is not contained in the ACRES database, so testing this relationship fully will require a comprehensive review of Phase II environmental assessments.

FUTURE RESEARCH DIRECTIONS

Given our results and the rich data available through the state and federal government, a *Maine Brownfields (research) Initiative* presents multiple avenues of inquiry into the impact and process of brownfields remediation within the state. The first step of the initiative would be to fill in the gaps in the ACRES database on future uses and spending on assessment and cleanups to assemble a full accounting of federal spending in the state. As shown in Table 2, there are many properties where activities, particularly cleanup activities, remain unaccounted for, which obscures the full extent of federal spending. Once a thorough accounting has been taken, the following set of research programs would assist the state and EPA in understanding the return on their brownfields investments.

Exploration of Urban and Rural Costs

One of our most striking results is the disparity between the cleanup costs and redevelopment duration between urban and rural properties, and we theorized that differences in future uses and the extent of contamination may help explain the difference. Testing this hypothesis could be done by verifying the completion of assessments and cleanups and taking a status census of land reuses in conjunction with the missing data survey to reveal future uses. The census would also include solicitation of any Phase II assessments not found in the Maine DEP database, to create a comprehensive set of information on the extent of contamination that could be put through a content analysis. Once reuses have been categorized and extent assessed, a causal model of redevelopment cost could be identified and estimated by combining the data with US Census and other data. Such a model would strengthen the strategic planning of Maine DEP and local practitioners' understanding of the cost hurdles associated with urban and rural redevelopment and allow for more comprehensive planning.

Maine's Brownfields and Public Health

Environmental remediations play a crucial role in mitigating public health hazards. For example, completing the cleanup of lead heavy Superfund sites has been found to decrease nearby children's blood lead levels (Klemick et al. 2020). While Maine, and New England writ large, have been recognized for their efforts in lead remediation (US EPA 2020b), similar examinations of such efforts' effect on lead exposure have yet to be carried out. Maine DHHS maintains detailed records of children's blood lead levels as a part of the effort to eradicate childhood lead poisoning by 2030 (Maine DHHS 2025). This puts Maine DEP and DHHS in a unique position to estimate the effect of lead remediation at brownfields on nearby children's blood lead levels with a more focused approach.

Economic Impacts of Redevelopment

Federal investments including EPA grants that enable the state and municipalities to fund assessments and cleanup activities, and their yearly impacts could be tracked through the state's (and local) economy. Specifically, grants are used to pay contracting services in the environmental consulting, remediation services, and construction industries, while also supporting community liaisons leading engagement efforts. Thoroughly accounting for these investments in the missing data survey would allow Maine DEP and EPA to estimate their immediate economic impact. Ideally, spent grant funding would be introduced as a government investment shock to an input-output model of the state economy, which can measure the multiplier effects of new and existing economic output (Leontief 1986). This model would give a reasonable estimate of the employment and direct economic output spurred by grant funding, as well as the downstream indirect effects of spending done by primary industries and induced by employee spending.

Beyond the immediate economic impact of the investment itself, EPA and Maine DEP benefit-cost analyses of projects would benefit from analysis of the longevity and productivity of reuses at completed projects. Including questions about employment and output on the land reuse census would allow for an estimation of the continued economic contribution of former brownfields to employment and output. In addition, a granular estimation of the impact on housing prices of brownfields remediation in the state could be conducted using the reuse census as well. Using quasi-experimental approaches similar to those of Haninger et al. (2017), the hedonic price impacts of different reuses could be assessed to determine the overall real estate value added by remediation.

Future Brownfield Identification and Inventorying

The inventory of former uses and contamination profiles that we created for our analyses provide a unique opportunity to match current uses with potential contamination. While Maine DEP's current inventory is thorough, it is mostly based on federal databases and reports from municipalities and local organizations. As a result, it is mostly reactive because it is based on current reports. A proactive inventory of potentially contaminated properties could be introduced to augment the existing list for anticipatory remediation and redevelopment planning purposes.

Inventories of this type are generally constructed using tax assessor data, inventories of underground and aboveground storage tanks, and other potentially pertinent datasets (Foley et al. 2021). The former use and contamination profiles we have constructed could be linked with these types of datasets from the state, which would allow for a greater level of precision in identifying and prioritizing sites with a higher probability of contamination along with their potential contaminants. The sites can then be overlaid with socioeconomic indicators to develop state-, region-, and community-wide priority assessments to target sites with the highest probability of contamination in areas with the greatest need.

SUMMARY

We have presented an analysis of Maine's urban and rural brownfields that compares the redevelopment processes, former uses, and contamination frequencies between them. We found that rural redevelopments tend to take less time and cost less, and that there are some differences in contamination and former use profiles. We further hypothesize that these may be due to anticipated future uses, population densities, and the risk of future exposure posed by brownfields in each location. We finished by outlining future research needs to evaluate and enhance Maine's brownfields program and determine the return on investment expected by federal redevelopment funding. This constitutes a first step in the exploration of the impacts and costs of brownfields redevelopment in Maine, which we expect will reveal opportunities for process improvement and understanding of its benefits.

NOTES

1. "Superfund," US EPA, https://www.epa.gov/superfund
2. "Types of Funding," US EPA, https://www.epa.gov/brownfields/types-funding
3. "Regional Planning," Eastern Maine Development Corporation, https://www.emdc.org/services/communities/regional-planning/; "Brownfields," Androscoggin Valley Council of Governments, https://www.avcog.org/1104/Brownfields; "Community Development," Our Katahdin, https://www.ourkatahdin.com/our-work/community-development/; "History," Children's Museum and Theater of Maine, https://www.kitetails.org/history
4. "Cleanups in My Community," US EPA, https://www.epa.gov/cleanups/cleanups-my-community
5. "TIGER/Line Geodatabases," US Census Bureau, https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-geodatabase-file.2020.html
6. "North American Industry Classification System – NAICS," US Census Bureau, https://www.census.gov/naics/
7. "Producer Price Index by Commodity: All Commodities [PPIACO]," US Bureau of Labor Statistics, retrieved from FRED, Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org/series/PPIACO
8. "Polycyclic Aromatic Hydrocarbons (PAHs)," Agency for Toxic Substances and Disease Registry, https://wwwn.cdc.gov/tsp/substances/ToxSubstance.aspx?toxid=25
9. As defined in the Resource Conservation and Recovery Act 40 C.F.R. Part 261 (1980)

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