Mapping the Industrial Archeology of Boston

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Abstract: *In a pilot project initiated in September of 2001, the Boston Public Health Commission, in collaboration with the Department of Urban Studies and Planning at the Massachusetts Institute of Technology, developed a methodology for superimposing historical and present-day industrial land use data layers with demographic information and public health data. The goal was to identify and to possibly define a historical relationship between present-day public health concerns and past practices of land use within an urban environment. Historic data layers showing location and type of industries known to emit hazardous substances were interpreted from Sanborn Fire Insurance maps in the years 1888 and 1962. These historic industries, along with current-day industries listed under the Massachusetts Department of Environmental Protection Tier 21 and Major Facility databases, were classified according to the Standard Industrial Classification Manual published by the U.S. Department of Commerce, and linked to tables of hazardous chemicals associated with each type of industry. Using ESRI ArcView 3.2 GIS, the two historic data layers were then overlain with present-day census and public health data. A customized spatial filtering function was developed to highlight "hotspots" of significant industrial activity and the accumulated risk potential over a period of time. The result is an archeology of risk. The intent is to produce a planning tool for strategic environmental health intervention to serve professionals in government and the private sector, such as public health professionals, legislators, city planners, and environmental designers, as well as community-based organizations.*

Introduction

Despite improvements over the years in technical analysis and increased formal emphasis on multi-stakeholder participation, decision-making processes involving land use planning are often made with little or no relation to its site history. A parcel of land used for residential or commercial building might once have been a leather tannery, lead smelter, or foundry—land uses that are associated with the possible release of heavy metals. Add to this historic patchwork of successive industries the current mix of residential, commercial, and industrial zoning and land uses, and we are left with a complex tapestry of in situ conditions with environmental health concerns.

As land use changes over time, remnants of prior use are either demolished or buried beneath new constructions and are effectively rendered invisible. It is essential that we capture the invisibility of historical land use in terms of the chemical makeup of the land that resulted from previous land uses. This is because some chemicals may remain on the land long after their initial discharge, and these may still be toxicologically active. The threat of chemical contamination from previous land uses presents a critical need for public health intervention to prevent environmental hazards from adversely affecting today's susceptible populations. Moreover, the experience of place and the burden of incompatible land use are phenomena that derive meaning from a history of land uses that extend their legacy through time (Colten 1994, Gustafson 2001, Lejano and Ericson 2004).

A systematic methodology is needed to trace this industrial legacy. Information on exact types and amounts of chemicals used historically in industries of the past, and actual measurements of contamination found on any given parcel of land due to such prior land use, are undocumented and unavailable. Formal records from relevant governmental agencies, such as planning departments and assessors' offices, supply quantitative information about historical zoning codes, and, to a minimal extent, types of industries previously present. Such information is, however, limited by their decentralized, unsystematic, and generally inaccessible nature, and is not effectively incorporated into land use decision-making processes today.

This paper develops a systematic methodology for documenting and analyzing the industrial ecology of past industrial activities, in an effort to better understand present-day environmental risk. This pilot project has been developed jointly by the Department of Urban Studies in Planning at the Massachusetts Institute of Technology (MIT) and by the Boston Public Health Commission (BPHC). The use of geographic information systems (GIS) was crucial and catalytic to our project, which not only enabled the visual superimposition of historical and present-day industrial land uses, but also facilitated a time-series analysis of degrees of "hotness," or possible contamination levels, over our study area. Note that our research lies in the realm of qualitative analysis, as not enough data is available to give reasonable estimates of chemical use or release in past land uses.

Of course, we are not the first to realize the potential of GIS for enabling new modes of analysis. A number of researchers are presently using GIS to screen areas for potential brownfields or to optimize brownfields redevelopment (Litt 2002, Thomas 2002).

Figure 1. The neighborhoods of Roxbury and Jamaica Plain are shaded in darker gray, within the lighter-gray context of the City of Boston, Massachusetts.

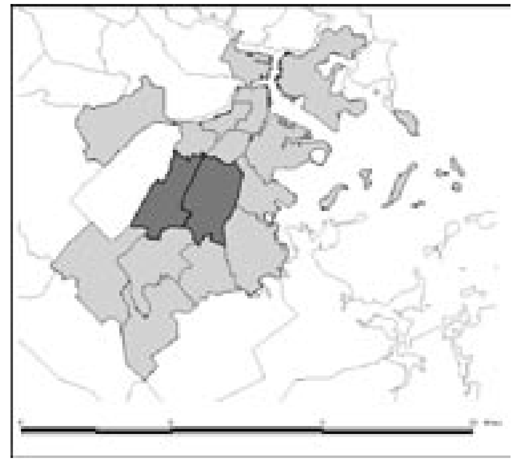


Figure 2. Neighborhood boundaries of Roxbury and Jamaica Plain are shown in bold, beneath which are shown census tract denominations of the same neighborhoods comprising our study area.

There is a growing body of knowledge on the use of GIS for assessing potential exposures to toxics (Guthe et al.1992, Zhang et al. 1996, O'Dwyer 2001, Gonzalez et al. 2002). At the same time, other researchers use mapping to illustrate historical land use succession. We attempt to link all these areas and relate history, land use, and community vulnerability. We also draw insights from the growing use of GIS in the area of archeology (e.g., Fry et al. 2003), the only difference being our application to an urban setting. The team was probably most influenced by concepts from the field of public participation GIS, or PPGIS (Obermeyer 1998, Cinderby 1999), wherein GIS is used as a medium for bringing out new ways of understanding or interpreting situations. Indeed, as we have attempted to do, some proponents of PPGIS have realized its power for bringing out community narratives, even linking the present situation to its history (Harris et al. 1995, Al-Kodmany 1998, Ghose 2001).

Study Area

The city of Boston, Massachusetts, shaded in lighter gray in Figure 1, has had a long and rich history of varied industries and land uses. Over the past 350 years, Boston's central landmass has more than tripled, attributed mainly to the annexation of nearby towns but also due to an expansive landfill project that created Back Bay, a portion of the Financial District and the new face of Boston's waterfront (City of Boston, Neighborhood Homepage, found at http://www.cityofboston.gov/neighborhoods/default.asp). Present-day Boston is comprised of 20 neighborhoods stretching an area of roughly 48.4 square miles. Our study area for this pilot project involved the neighborhoods of Roxbury and Jamaica Plain, shaded in darker gray in Figure 1, chosen due to the area's conspicuous industrial history. Ensuing research will aim to cover other neighborhoods in Boston using the same methodology. Our study area is demarcated by the census boundaries of Roxbury and Jamaica Plain, and the unit of area for our analysis is the census tract (Figure 2). We used a 1990 census tract boundary to map risks of industrial facilities that existed in three different time periods: 1880, the 1960s, and 1997. However, there is a caveat in the consideration of the geographical boundaries of different time periods for analysis. The town boundaries of the previous years and the current ones do not match. Therefore, there are some facilities that lie beyond and are not included in the present boundaries of the towns considered under the study.

Methods

This project was carried out in three phases: 1) heads-up digitizing and data entry of location and type of industrial facility present over three time periods; 2) identifying chemical pollutants that were likely to have been generated by each historical industrial facility, and determining their relative hazard levels; and 3) GIS data analysis.

Sanborn Fire Insurance maps from the years 1888, 1962, and 1968 were used as our primary source of historical data. They provided detailed and comprehensive information about the type of industry present at the time and its inferred land use, building typology, building footprint, and limited physiographical details about the landscape such as the presence of bluffs and streams.

The heads-up digitizing process began with a careful surveillance of Sanborn sheet maps to identify any industrial facility historically associated with the use of various toxic chemicals. Facilities that were considered relevant included metal foundries, breweries, auto-repair shops, sheet metal works, gasoline stations, dry cleaning operations, and hospitals, to name a few. Using ArcView, each of these industrial facilities was manually entered as point features on base maps (derived from the 1997 Boston parcels) at geographical orientations that roughly corresponded to the original Sanborn maps. In some cases, the street layout depicted in Sanborn maps of 1888 or 1962 did not match up or resemble that of the 1997 Boston parcels theme; in these instances, we referenced perennial landmarks and historical, intact buildings to best locate corresponding geographical locations between the

Sanborn and 1997 parcels maps. The 1888 data layer consisted of facilities found in the 1888 Sanborn map, and the 1962 data layer resulted largely from the 1962 Sanborn map, but also from a nominal portion of the 1968 Sanborn map in the interest of achieving the spatial integrity of our study area. Both the 1888 and 1962 data layers included three base themes: 1997 Boston parcels, 1997 TIGER (Topologically Integrated Geographic Encoding and Referencing) roads, and Ortho-photos. Then, a third data layer containing information on current (i.e., 1997) industrial facilities was created using the Massachusetts Department of Environmental Protection (DEP) Tier 21 and Major Facility databases.

Attributes of each point in all three data layers included a unique identifier, the name of the facility as it appears in either the Sanborn maps or the Tier 21/Major Facility databases, and type of facility classified by the Occupational Safety & Health Administration's (OSHA's) Standard Industrial Classification (SIC) code (U.S. Department of Labor). For the two historical layers of 1888 and 1962, SIC codes were manually assigned to each industrial facility using the 1987 SIC Manual Search Website offered by OSHA at http://www.osha.gov/oshstats/sicser.html. This page allows users to access descriptive information for a specified 4-digit SIC by entering key words pertinent to the type of industrial operation. For example, for a leather tannery, we would enter the keyword "tannery" into the search prompt, and receive back a SIC code associated with this operation: "3559: Scouring machines, tannery." When presented with several options, we read through the descriptions for each SIC code and determined which code seemed most appropriate for the industrial facility in question. When the search provided no results, we examined the manual structure of SIC classifications and searched for the most appropriate code. When information from the Sanborn maps proved insufficient to determine the nature or scale of the industrial activities carried out in a particular facility, we resorted to leaving the SIC classification field blank in our data. Researchers frequently consulted with one another to standardize the assigning of SIC codes, in order to bring differences between personal judgments to a minimum.

After classifying each industrial facility according to SIC codes, we then tabulated types of chemical contamination associated with each SIC code using the federal CERCLIS (Comprehensive Environmental Response, Compensation, and Liability Information System; Superfund, http://www.epa.gov/enviro/html/cerclis/cerclis/cerclis_query.html) and ARIP (Accidental Release Information Program, http://d1.rtknet.org/ari) databases, and the Massachusetts TURA (Toxics Use Reduction Act, http://www.turi.org/tuirdata) database. For this research, the entire historical CERCLIS, 1999 ARIP, and 1997 TURA data sets were used. Specifically, look-up tables were prepared in which specific chemicals were attributed to specific SIC codes based on information recorded from historical incidences of contamination and spills. We then linked each industrial facility with commonly associated pollutants by using the look-up table to match up the SIC codes. Though the SIC classification system is being replaced by the newer NAICS (North American Industry Classification System), we decided to use the former because the CERCLIS and other databases have historically listed businesses according to their SIC codes.

Ranking Hazards of Place

Starting with the mapping of historical facilities and linking each to their associated contaminants using the chemical look-up table, we then proceeded to developing a qualitative ranking methodology. We devised two ranking systems, each tailored to suit different ways of analyzing the resulting panorama of industrial archeology. One ranking system involved imposing similar ranking scales to facilities in all three data layers, regardless of the passage of time since the chemicals were originally used. This ranking system is amenable to observing snapshots of the industrial landscape in each data layer from a contemporary perspective, as if taking on the perspective of a surveyor in 1962 when looking at the 1962 data layer. The second ranking system took into account both the passage of time and the volatility of chemicals, thereby allowing for a cumulative view of risk over the three time periods from the perspective of the present.

The first method was a relatively simple one in which we grouped contaminants according to three categories:

Hazard Ranking 1	Volatile Organics	e.g., toluene
Hazard Ranking 2	Hydrophobic Organics, Soluble Metal Compounds	e.g., PAH
Hazard Ranking 3	Heavy Metals	e.g., lead

This is actually an ordinal system for ranking because the higher the ranking, the more persistent the chemical in the soil. This allows the user to query the database for parcels classified with Hazard Ranking 3 to bring up those parcels that have the highest likelihood of residual contamination. On the other hand, querying the database for hazard Ranking 1 would bring up areas where the surrounding population would be most vulnerable to airborne air toxics.

The idea behind this was intuitive: the higher the ranking, the more likely the contaminants are to stay soil-bound for longer periods of time. Using this ranking scheme, we assigned a Hazard Rank to each of the facilities represented on the 1888, 1962, and 1997 data layers, based on the types of chemicals likely to have been discharged as determined from the chemical look-up tables mentioned earlier. If we were unable to attribute specific chemicals to an SIC code using the chemical look-up tables, it followed that we were unable to assign a Hazard Rank to facilities classified under that SIC code for lack of information.

The second method went a step further, and considered the passage of time as a determinant factor of chemical potency. That is, we assumed that the effect of volatile organics released in the year 1888 will most likely have expired during the passage of time, and will pose little or no threat to the contemporary landscape. Following this logic outlined in the table below, we used a binary system of ranking wherein facilities that are either: I) classified as Hazard Rank 3; II) classified as Hazard Rank 2 and were active sites from the 1960s or later; or III) classified as Hazard Rank 1 and were/are active sites from the 1990s or later, were assigned a point whereas the rest received none (Figure 3).

The intuition is that a volatile organic (Hazard Rank 1) would not remain on the soil beyond a decade or so and, thus, would not be expected to carry over from, say, 1962. The intention behind both ranking systems was not to be able to quantify the severity of contamination, which is impossible without sampling every parcel within the study area, but rather to discover areas of relatively heightened industrial activities and their spatial patterns over the years, and to provide information by which intervention measures may be planned in the present and future through a more comprehensive full acknowledgement of the past.

Spatial Filtering and Hotspots

Application of GIS for this project consisted of incorporating customization tools into ArcView 3.2 GIS, one of which is the "spatial filtering" tool that adds up point feature values within a polygon feature (Figure 4). This enables users to add up the hazard rankings of facilities or the number of sites within each Census tract polygon. This new sum field was then used to create thematic maps identifying areas of heightened industrial activities, or areas designated as "hotspots," and potential risks to public health.

Although the applied spatial hotspot detection method quantifies the hazard rankings, it is quite simple as it does not consider any statistical analysis. More complex spatial hotspot mappings, such as cancer cluster detection software, provide

	1888	1962	1997
Hazard Rank 1	Obsolete	Obsolete	Active
Hazard Rank 2	Obsolete	Active	Active
Hazard Rank 3	Active	Active	Active

Obsolete = 0 point
Active = 1 point

Figure 3. The cumulative hazard ranking system

the statistical ability to detect cold spots (lower than expected number of cases) in addition to hotspots (higher than expected number of cases). High positive spatial autocorrelation can be generated by low values close together (cold spots) as well as by high values close together (hotspots) (Lee and Wong 2001). There are more than 100 statistical tests available for cluster assessment (Kulldorff 2002). Some of these are appropriate for focused tests (clustering of cases around a known exposure location), others for unfocused tests (clustering in general), and still others make restrictive assumptions about the data. The user needs to consult with a statistician to determine the most appropriate method to use for a particular data set.

Methodological Limitations and Practical Constraints

Many assumptions were made in the processes described above that compromised the rigor of our analysis in the proceeding section. First, the problem of inconsistency was inevitable when personal judgment accounted for much of the process of assigning SIC codes to industrial facilities. Sanborn maps often did not provide enough information about the precise nature and scale of industrial activities at specific sites, thereby necessitating the researcher to make his or her best educated guess; these guesses were invariably biased and may not have always concurred with one another or failed to capture the industrial operations that actually took place over time in a given facility. Second, the problem of documentation must be considered as a major setback when it is clear that not all hazardous facilities were documented both by the Sanborn maps and the DEP databases. It must be noted that Sanborn maps were commercial in purpose, catering to the needs of insurance companies assessing the risk of fire hazards when insuring properties. This meant that Sanborn maps only documented areas where people would and could invest in fire insurance; thus, it is conceivable that underpopulated or economically disadvantaged communities have not been documented for lack of demand. However, it is precisely in areas of lower socioeconomic status that hazardous facilities are often located, and this proves to be another compromising factor in our analysis. In addition, we recognize the problem of generalization in all stages of assigning risk to each facility. Not all facilities having the same four-digit SIC denomination are likely to follow identical methods

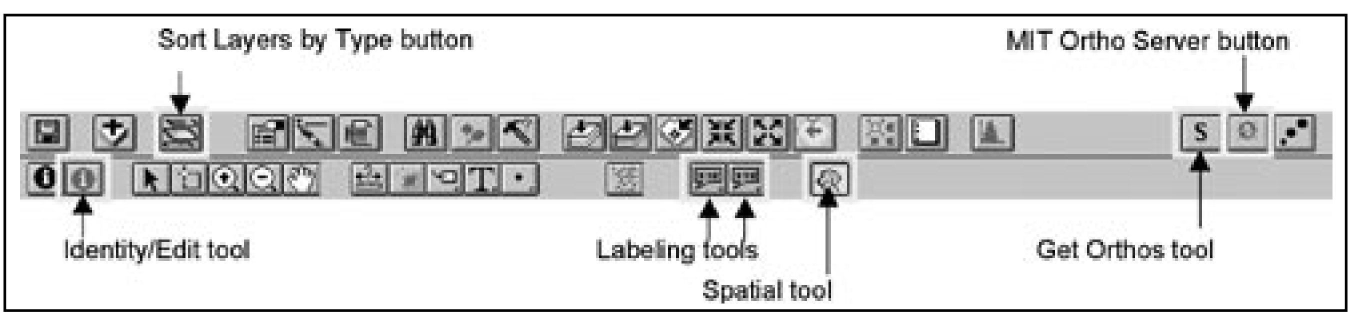
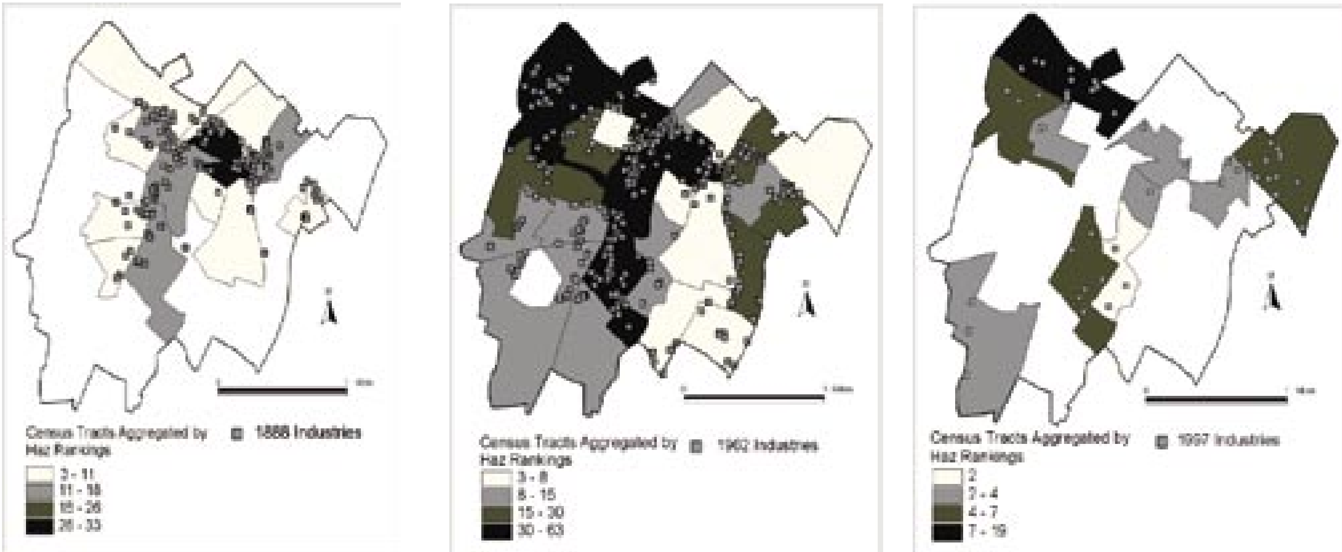


Figure 4. Customized GUI showing buttons and tools



Figures 5, 6, and 7. Time Series maps showing industrial facilities and aggregate hazard rankings in Roxbury and Jamaica Plain over three time periods

of production and thus emit identical chemicals; also, not all chemicals will behave in the same manner and persist over equal lengths of time. Our project did not take into account probable variations in the fate and transport of chemicals.

In choosing data layers that would best represent historical trends in industrial activity within Roxbury and Jamaica Plain, we selected only three data layers due to both time constraints and completeness of data. The lack of historical continuity in the database prevents us from making stronger observations about what forces shape these historical trends. The availability of Sanborn maps has been a limiting factor in determining the selection of the historical time periods we have used in this study: 1888 and 1962. The completeness of coverage is another factor, for example, the 1921 map only had a partial coverage of the Roxbury area, which precluded its use in our study. Because of this limitation, our study itself resorted to combining two different Sanborn maps for the period 1962 data layer. The part of our study area that was not mapped in 1962 was augmented by later documentation in 1968. In order to generate one whole picture of the study area, we combined the two data layers mapped during the 1960s. This was done with the assumption that, given the overall time frame of this study, extending from 1888 to 1997, there would be little relative change in the size and characteristic of industrial development in the study area during the time interval of six years.

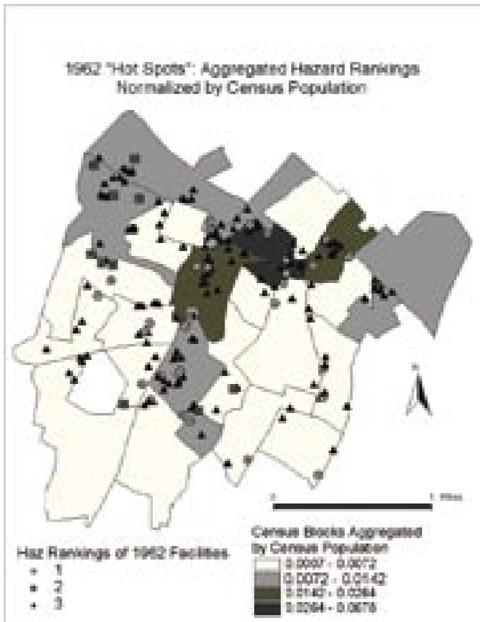
As always, the analysis is constrained to the polygons that are available for aggregating or averaging data—in this case, census tracts. While conveying averages, densities, and other statistics on a tract basis is the simplest for the user to understand, more precision could be obtained by using a moving window or other technique for aggregating data.

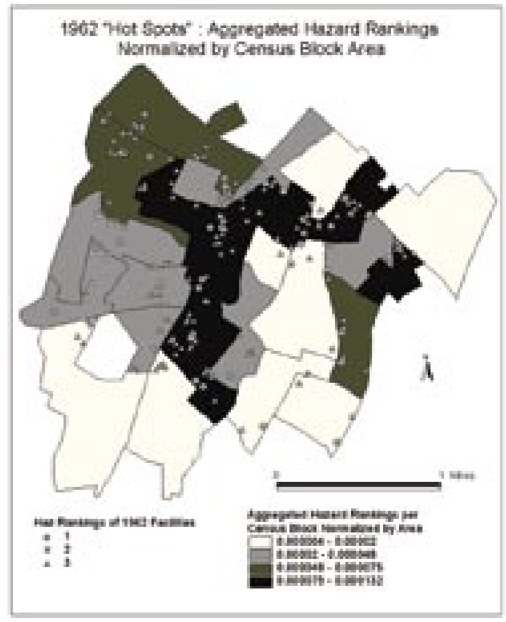
The primary practical constraint to this type of research, however, is quite simply the effort required in studying old maps, extracting relevant information, and translating this into GIS through "heads-up" digitizing, and, typically, one can only process a handful of old industrial sites in an hour.

Analysis and Discussion

The methodology described above produced maps showing the magnitude and spatial orientation of industrial activities over three points in time, which translate into environmental risks likely to have accumulated over time on current-day parcels in Roxbury and Jamaica Plain. Our analysis mainly consisted of two parts: Time Series mapping and Composite Overlay mapping. The Time Series map looks at the number and spatial orientation of noxious facilities, the extent and spatial orientation of hotspots, and other relevant analysis at different points in the industrial history of our study area. In essence, they represent snap shots of past industrial landscapes as seen from a contemporary perspective. Thus, an 1888 mapping of hotspots is seen from the perspective of an observer situated in 1888, which could then be compared to a 1962 data layer, as seen in 1962, and so on, enabling planners and historians to peer into the history of land use and spatial patterns of change. Through the use of Time Series mapping, we can investigate various environmental planning and public health problems. One practical application would be to determine efficient allocation of funds toward brownfield remediation, in a manner that would target only those tracts having hazard rankings above a certain threshold.

The Composite Overlay, on the other hand, results from the second ranking method wherein the passage of time becomes a factor in determining the viability of chemicals. This allows all three layers to be superimposed onto one map that shows the cumulative effect of industrial activities over time and highlighting areas of heightened environmental risk in our contemporary landscape. This tool is extremely useful for public health professionals in determining intervention strategies in a most efficient,





Figures 8 and 9. Maps showing normalized hazard rankings

need-based manner. Through these analyses, we addressed some of the most commonly asked planning questions, such as:

- Where are the areas that have the highest concentration of hazardous facilities?
- Which are the tracts having the highest number of people exposed to environmental risks posed by these facilities?
- What spatial patterns are indicated over a period of series of years? Are the current hotspots located in the same area as in previous years?
- How are hotspots distributed over time?

Time Series Mapping

To create a Time Series map, we used the first hazard ranking methodology to produce the maps seen in Figures 5–7. The first map (Figure 5) shows "hotspots"—or areas likely to have above-average risks to public health due to industrial activities—in Roxbury and Jamaica Plain around 1888. The hotspots are based on cumulative hazard rankings of industrial facilities contained within each census tract. The darker the shading, the greater is the level of hazard potential. These maps essentially show contemporary risk; that is, the hotspots shown in Figure 6 related to risk experienced by the residents of Roxbury and Jamaica Plain around the year 1962, and does not necessarily relate to how risk is distributed in the modern landscape nor necessarily reflect hotspots back in 1888. That said, there seems to be a general clustering of hotspots along a central corridor of both neighborhoods in all three data layers, and the spread of industrial activity seems to have traveled northeastwards before dispersing in the marginal corners of the two neighborhoods. This trend seems to make sense in light of the existence of a major transportation corridor along the border of Roxbury and Jamaica Plain, namely the railway. Note the presence of blank areas in the mappings—these correspond to areas that were not included in the fire insurance maps.

However, risk, expressed simply as the summation of hazard rankings of individual facilities within each census tract, will not be amenable for comparison with other hazard maps from different times and places, because the areas to be compared may be disproportionate in nature in terms of their sizes, population density, income levels, and other relevant parameters. Therefore, in order to obtain comparable data across different data layers, we normalized the aggregated hazard ranking by the indicator by which we want to measure the hazard potential (Figures 8 and 9). For example, for producing risk mapping based on density of hazardous facilities, we normalized the aggregated hazard ranking of the tract by its area. The second set of maps is the outcome of this normalization and narrows down the hotspots to only those areas having high-density hazard potential (that is, a high concentration of hazard facilities. Because the denominator is the unit area of tract, we can now eliminate all those tracts that have disproportionate hazard levels.

Some census tracts have a higher population density than others, and as such these areas have different levels of population exposure to the risks. Therefore, we normalized the aggregated hazard rankings by the number of people in each tract, and produced the third map, which quantified risk in relation to the number of people exposed to the hazardous facilities.

The darker the shading, the greater is the degree of potential impact (for which population density is a relevant indicator) to the residential community. These mappings can be used for planning health interventions, such as siting health outreach centers. By selecting the most darkly shaded tracts having the highest degree of risk and the largest population density, we can now efficiently allocate resources toward health facilities for serving the largest affected population. Similarly, by normalizing by other indicators, we can answer other questions, such as which tracts may have the highest juvenile exposure to environmental hazards, and which ones are located in located in low-income areas.

Similarly, by overlaying a layer of groundwater aquifer zones, we can produce other areas of overlap that are most vulnerable to groundwater contamination.

Overlaying Demographic Data

Having mapped the hotspots, we can further investigate different phenomena by overlaying different present-day environmental and health data layers. Layers showing blood lead levels and asthma rates in children may be overlain over the aggregate hazard mappings to begin searching for correlative effects. However, as cautioned above, this is just a decision support tool and is not a quantitative model (e.g., by which we can correlate disease prevalence quantitatively), because it brings together information of various types—not all quantitative, but also ordinal, qualitative, and even subjective data. Another caveat is that the population is mobile, and as such the people who were originally affected might no longer represent the sample and those who represent the sample either were not affected or were affected because of exposure unrelated to the nature of the particular areas. Furthermore, they might potentially be exposed to risks other than those that resulted from the hazardous facilities. Notwithstanding all this, this type of overlay mapping can lead to more reflective planning about connections between present-day phenomena and the history of land use. It is a logical extension of a basic methodology, land suitability analysis, pioneered by Ian McHarg (1969).

We can also prepare a composite showing hazard levels aggregated over all three periods (Figure 10). In the composite map, cumulative hazard rankings are calculated by simply summing the hazard rankings for only the sites that are considered active (referring to the rating system in Figure 3).

These mappings help answer questions such as where the "hotspots" might have been located over three different time periods, or whether or not there might be temporal trends in the variation of hazard risks in sensitive areas. The distribution of hazard potential in terms of population density exposure to industrial hazards shows varying patterns in three maps. Some of the tracts that used to have some hazard potential in 1988 seem to no longer pose risks in 1962. Vice versa, other tracts that did not house any hazardous facilities in 1988 are the sites of potential risk in 1962. This may be an indication of the changing movement of industrial sites over time. Nevertheless, if we focus on a few tracts in the western part of Roxbury, we find that this area remains a persistent hotspot through time. Because of the consistency in the level of hazard potential in this area, these tracts warrant sustained attention from both public health officials and environmental planners. These sights are the most vulnerable to environmental contamination and public health and might ask for maximum allocation of resources in terms of remediation

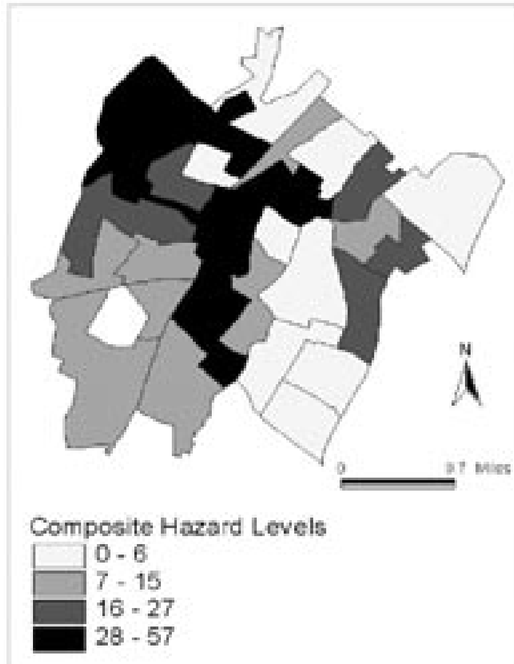


Figure 10. Composite Map Showing Cumulative Hazard Rankings Throughout 1888, 1962, and 1997 Data layerData layers.

projects and health services to the people living in the areas. In addition, more investigation may need to be carried out to actually determine the magnitude of the potential risks and to carry out the industrial archeology on a site-specific level (Stott 1984; Bergen 1990).

Conclusion

This pilot project has succeeded in producing a mapping tool for professionals in government and private industries to better gauge environmental risk accumulated over time. The investigators of this project explored various uses of such a tool to conduct research and design health intervention programs in a way that enables them to target the zones of the greatest concern. Moreover, communities can utilize this mapping tool as a community information system in an attempt to mobilize around issues of health and potential risk. Developers and communities, in partnership, can use the mapping to make better investment decisions and to allocate funds more aggressively for cleanup. The BPHC is seeking to expand the mappings to greater parts of Boston. Two of the first applications being contemplated are the use of the mapping tool for planning future remediation projects, such as using phytoremediation, and for educating youth about the history of their micro-environment.

This project has demonstrated that digital cartography, and the spatial database that goes with it, can greatly aid public health officials in visualizing risk, identifying the hotspots, and devising policy interventions accordingly. Furthermore, this project was an effort to move mapping beyond representations of concrete, immediate, spatiality and on to other complementary logics, whereupon we realized, upon reflection, that mapping has always been about more than just representing the physical. Overall, the maps have the potential to enhance the understanding of how many communities find themselves having to bear a history of neglect and, more importantly, improve the possibility of creating a better and healthier future for these communities.

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