Assessment and Application of National Environmental Databases and Mapping Tools at the Local Level to Two Community Case Studies

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ABSTRACT

Communities are concerned over pollution levels and seek methods to systematically identify and prioritize the environmental stressors in their communities. Geographic information system (GIS) maps of environmental information can be useful tools for communities in their assessment of environmental pollution-related risks. Databases and mapping tools that supply community-level estimates of ambient concentrations of hazardous pollutants, risk, and potential health impacts can provide relevant information for communities to understand, identify, and prioritize potential exposures and risk from multiple sources. An assessment of existing databases and mapping tools was conducted as part of this study to explore the utility of publicly available databases, and three of these databases were selected for use in a community-level GIS mapping application. Queried data from the U.S. EPA's National-Scale Air Toxics Assessment, Air Quality System, and National Emissions Inventory were mapped at the appropriate spatial and temporal resolutions for identifying risks of exposure to air pollutants in two communities. The maps combine monitored and model-simulated pollutant and health risk estimates, along with local survey results, to assist communities with the identification of potential exposure sources and pollution hot spots. Findings from this case study analysis will provide information to advance the development of new tools to assist communities with environmental risk assessments and hazard prioritization.

KEYWORDS: Community Maps, National Air Toxics Assessment, Air Quality System, National Emissions Inventory, Geographic Information System

1. INTRODUCTION

Collaborative efforts, spanning from the international to the local level, are increasingly being used to address the complex environmental problems facing societies. At the local level, numerous studies have shown that a primary deterrent to community participation in environmental advocacy efforts is a lack of understanding of the relationships between pollutant sources, concentration levels, exposures, risks, and associated health impacts [1-3]. Hence, community groups and residents have expressed the need for easy-to-understand tools to assist with their community environmental risk education and assessment initiatives [4]. To address this need, governmental agencies including the Environmental Protection Agency (EPA), the Centers for Disease Control and Wellness Promotion (CDC) and the National Institute of Environmental Health Sciences (NIEHS) have developed funding programs aimed at advancing the science and community understanding of potential exposures and risks to environmental pollutants and sources.

The EPA's Community Action for a Renewed Environment (CARE) program is one such program that works in collaboration with scientists in the EPA's Office of Research and Development (ORD) to develop community-focused exposure and risk screening tools that community groups can use to identify their local environmental hazards and provide information to aid in prioritization [5]. The EPA established the CARE program in 2005 to promote community involvement in the environmental risk assessment and risk reduction process [6]. The program is designed to provide financial and technical assistance to communities to develop partnerships to identify, prioritize and address environmental stressors of concern. Additional information on the CARE program is available on the CARE Program website (http://www.epa.gov/CARE/). The CARE program is a nationwide program that involves

multiple community classifications (*e.g.*, geography-based, ethnicity-based, environmental issue-based, etc.) and, thus, is a fitting program to draw generalizable results on how GIS mapping tools can be used to increase the understanding of environmental exposure and health risks among community groups.

Many communities that undertake risk assessment projects, including CARE grantees, find the information gathering and organization process an important, yet daunting, task given budgetary, time and resource constraints. The CARE Program has responded to this need by providing guidance to community grantees in various forms. At the onset of funding, the program assigns each CARE project a project officer, an advocate from the appropriate EPA regional office, to serve as a technical resource. In addition, the CARE program offers a 10-step process, referred to as the CARE Roadmap [7], to guide grantees through the process of identifying community concerns and building long-term capacity to understand and reduce the identified concerns through effective actions. As described in the CARE Roadmap [7], CARE communities are advised to follow the following steps: 1. Build a partnership; 2. Identify community concerns; 3. Identify community vulnerabilities; 4. Identify community assets; 5. Identify concerns for immediate action; 6. Organize available information; 7. Rank risks; 8. Identify potential solutions; 9. Set priorities and take action; and 10. Evaluate results and revisit priorities. The CARE Roadmap encourages communities to take action on known risks at the beginning of the process, and suggests practical ways to collect and analyze the information needed to build consensus and target risk reduction efforts where they will have the greatest impact. Community groups not affiliated with the CARE program often follow a similar process to the CARE Roadmap using suggestions provided by the Protocol for Assessing Community

Excellence in Environmental Health (PACE EH), the Community Air Screening How-To Manual, or other community guidance documents [8-9].

Although there are several guidance documents available to communities to inform the information gathering process, many communities find them overwhelming because of their size, scope and technical jargon. Barzyk et al. [10] provides a summary of the EPA-developed tools available to communities to assist in the identification and prioritization of local environmental issues. The article supplies information on relevant guidance documents, exposure models, and mapping tools designed or suitable for community use. Examples of such EPA mapping tools include Enviromapper Storefront [11], the Toxic Release Inventory (TRI) Explorer [12], and AirNow [13], which are GIS interfaces of underlying national databases. These mapping tools have been used by communities to identify areas of greatest risk; however, many communities seek techniques to map environmental information at a more refined spatial scale using a combination of national, local, and community-generated databases.

The research presented in this paper focuses on two interconnected analyses. This study presents an assessment of multimedia EPA databases and mapping tools to inform community risk assessments and a process for community application of selected EPA databases with two case study examples. The case study analyses included in this study were conducted in collaboration with the CARE program to provide community-level pollutant concentration and health risk GIS maps using a combination of national, local, and community-generated databases to address information gaps identified by the community partnerships.

2. BACKGROUND

The EPA project officers of the CARE projects in Detroit, MI (Wayne County) and Holyoke, MA (Hampden County), (hereafter referred to as Detroit CARE and Holyoke CARE,

respectively) requested assistance from ORD in developing GIS maps to support their efforts to identify and prioritize local environmental concerns based on potential impacts on community health. The Detroit CARE and Holyoke CARE projects are both Level 1 projects that began receiving CARE funding in 2006. Level 1 projects attempt to work through to step 7 on the CARE Roadmap. The Detroit CARE project is led by Southwest Detroit Environmental Vision (SDEV), a local non-profit organization focused on improving environmental quality in Southwest Detroit. Over the past fifteen years, SDEV has carried out program initiatives in the areas of contaminated sites redevelopment, pollution prevention, illegal dumping prevention, air quality, land use, environmental justice and environmental education. More information on SDEV can be found on the internet at http://www.sdevweb.org. Nuestras Raíces (NR), a grass-roots organization that promotes economic, human and community development in Holyoke, Massachusetts through projects relating to food, agriculture and the environment, serves as the organizational lead of the Holyoke CARE project. NR was founded in 1992 by the members of La Finquita community garden in South Holyoke to build cultural pride as well as the ability of low-income Latinos in Holyoke to address environmental, economic development, substance abuse, and food security issues. More information on NR can be found on the internet at http://www.nuestras-raices.org.

Through their respective EPA project officers, the Detroit CARE and Holyoke CARE projects provided ORD with a core list of priority issues. The Detroit CARE project, through a series of community meetings with residents and local stakeholders, identified three primary categories of environmental issues related to chemical stressors and asthma concerns: air pollution from major point sources, truck traffic, and illegal dumping. The Holyoke CARE

project identified mobile vehicle exhaust (including diesel trucks), auto body shops, drinking water, asthma, and water quality as their issues of top concern.

To make the most efficient use of available resources, several criteria were used to select the specific pollutants and environmental concerns to address in this GIS mapping case study analysis. The selected pollutants or environmental hazards would need to be considered a priority concern by both community partnerships, be regulated by the U.S. EPA, and have suitable measurements available for GIS mapping of the hazard or pollutant at the census-tract level. This paper will focus on the development of GIS maps related to the specific air pollutant concerns identified by the Detroit CARE and Holyoke CARE projects. The air quality-related pollutants were chosen for this case study analysis over the other media concerns because, given the selection criteria, the air quality-related concerns provided an optimal scenario for an effective evaluation of the mapping tools, databases and community-specific GIS maps: both projects identified concerns related to air quality, the U.S. EPA regulates multiple air pollutants and source categories, and the air quality databases to support a mapping application are more advanced spatially compared to other media. Future research will consider other issues such as water quality, land use and the effects of non-chemical stressors on human health risk.

3. METHODS

Two investigations were conducted as part of this study and discussed in this paper. First, a review of current EPA spatial mapping tools was conducted to determine the features that would be useful in a community risk assessment. Secondly, the information gained from the review was used to develop a GIS community mapping process and community-specific maps for two EPA CARE projects.

3.1. Review of EPA Spatial Mapping Tools

The tools discussed as part of this paper are the EnviroMapper Storefront, the TRI Explorer, and AirNow. EnviroMapper Storefront is a screening-level umbrella tool that allows the user to map multiple types of environmental information, such as air releases, water discharge permits, and Superfund sites, by accessing separate EPA databases and other mapping tools, such as My Environment [14]. The maps generated using Enviromapper Storefront use coordinate specific records (i.e., point sources, monitor locations, schools, etc.) which provide the user with a location map of environmental point data. In comparison, the TRI Explorer uses choropleth maps, a map which colors regions or areas according to the emissions value defined for that area, which enables a user to better compare areas across a region or locality. Maps generated using the TRI Explorer use cyan, yellow and red to indicate low, medium and high emissions, respectively.

Lastly, AirNow provides maps that display information related to the Air Quality Index (AQI) [15], a measure of air pollution levels and the related potential health concern for a particular locality, for cities across the nation. However, the AQI is calculated for only five of the air pollutants regulated by the Clean Air Act (ground-level ozone, particle matter (PM), carbon monoxide, sulfur dioxide, and nitrogen dioxide). Other pollutants that have been associated with adverse health effects, such as hazardous air pollutants (HAPs; acetaldehyde or ethyl benzene), are not factored into the AQI calculation.

Enviromapper Storefront, the TRI Explorer and AirNow each provide desirable features for inclusion in a community-level GIS mapping project. Enviromapper Storefront allows the user to adjust information layers (i.e., roadways, monitors, etc.) to create maps tailored to specific concerns. The census-tract aggregations supplied by the TRI Explorer provide a means

to compare ambient emissions across nearby communities or neighborhoods which could be used to compare other aggregations such as health outcomes. AirNow displays quantitative health risk information in a logical color-coded format to efficiently communicate risk levels across a geographical area. The maps generated for this study will incorporate the advantageous features of these EPA mapping tools. Although the current mapping tools provided by the EPA consist of several informative features for community users, the tools operate independent of one another which complicates and potentially minimizes usability.

Based upon the review of the aforementioned mapping tools, several features were identified as missing from some or all of the current EPA mapping tools that may be useful to community users: integration of mapped data (i.e., air monitor values, facility emissions and community locations of interest on a single map), multi-pollutant framework (i.e., the ability to map pollutants together that are affiliated with similar sources), inclusion of community-generated information (i.e., community monitoring results, survey results, etc.), and emphasis on health-based risk estimates (i.e., asthma prevalence, cancer risk, etc.). Using these criteria, GIS maps were developed for the Detroit CARE and Holyoke CARE projects using information obtained from several national databases to assist the projects with their community risk assessments and to provide information to support local mitigation decisions.

3.2. GIS Community Mapping Process and Case Study Application

Figure 1 depicts the process employed to develop the maps for the Detroit CARE and Holyoke CARE projects. This 8-step process was developed in collaboration with the EPA project officers and CARE grantees to support future GIS mapping projects within the CARE program and provide general guidance to other community partnerships. The community provides information on the location of interest and the chemicals or pollutants of concern in

Steps 1 and 2. Steps 3 through 5 focus on gathering and compiling the appropriate spatial information from suitable national and local databases. The creation of the maps, process for mapping additional pollutants or chemicals of concern, and community evaluation of the maps are covered in Steps 6 through 8, respectively. A description on how this process was applied to the GIS community maps created for the Detroit CARE and Holyoke CARE projects follows.

After choosing a geographic region of interest (Step 1), the community selected specific pollutants or chemicals of concern (Steps 2 & 7) based on known associations with identified concerns. The communities included in this study had previously identified specific issues of concern; however, many community partnerships experience difficulty selecting specific issues and, in those cases, the community may consider consulting residents and local health or community-based organizations for input (Step 2b) before beginning a GIS mapping project [16]. Because the Detroit CARE project acknowledged point source pollution and traffic as primary air quality issues of concern, the selected pollutants of interest were diesel PM, elemental carbon, benzene, coke oven emissions, nitrogen oxides, lead, manganese, arsenic, and nickel. Ambient concentrations of heavy metals and coke oven emissions are typically used as markers for large facilities, such as waste incinerators, power plants, blast furnaces and steel mills [17]. Diesel PM and elemental carbon are routinely used as surrogates for diesel exhaust in air pollution studies [18-19], and standard markers for gasoline vehicle exhaust include nitrogen oxides and benzene [20-21]. The pollutants of interest related to the air quality concerns identified by the Holyoke CARE project include: diesel PM, elemental carbon, lead, nickel, manganese, and copper. Emissions of heavy metals such as nickel, manganese, lead and chromium, have been linked to auto body refinishing shops [22].

Once the pollutants of concern were identified by the projects, relevant concentrations, sources and health risk estimates were necessary to develop the maps (Step 3). The EPA maintains multiple databases that provide publicly-assessable information on air pollutants suitable for mapping purposes. These include the National-Scale Air Toxics Assessment (NATA), the TRI, the National Emissions Inventory (NEI), the Air Quality System (AQS) and AirData. Information from these databases can be downloaded in multiple formats including those suitable for word processing and spreadsheet programs. NATA provides model-based census-tract level concentration, exposure and cancer risk estimates, along with state and county averages, on over 189 pollutants identified as air toxics (i.e., benzene, acetaldehyde, toluene, etc.). The NATA assessments are conducted every three years and the results are made available to the public at http://www.epa.gov/ttn/atw/natamain/. Currently, the most recent NATA available for public use is the 2002 assessment.

Two national databases report location and emissions statistics for point source facilities: the TRI and the NEI. The TRI (http://www.epa.gov/tri), the underlying database for the TRI Explorer, contains information on toxic chemical releases and waste management activities reported annually by certain industries as well as federal facilities. Approximately 650 chemicals are included in the TRI (i.e., nickel compounds, chromium compounds, etc.). The NEI (http://www.epa.gov/ttn/chief/eiinformation.html) is a national database of air emissions information that includes input from numerous state and local air agencies, tribes, and industry. The NEI contains information on stationary and mobile sources that emit criteria air pollutants and their precursors, as well as HAPs. The most recent NEI update available for public use is the 2002 release. NEI and TRI supply similar facility information, but differ in data collection methods. TRI relies on self-reported emissions from facilities while NEI uses estimates from

facilities in conjunction with permitting information from local monitoring agencies [23]. The facility emissions estimates used to develop the maps for the Detroit and Holyoke CARE projects were compiled using only the NEI to provide database consistency. The NATA assessments are based on the stationary and mobile source information provided by the NEI. Lastly, in regard to air monitor concentrations, the AQS (http://www.epa.gov/ttn/airs/airsaqs/) includes ambient air pollution measurements for criteria pollutants (i.e., ozone, PM, sulfur dioxide, etc.) collected by EPA, state, local, and tribal air pollution control agencies from thousands of monitoring stations throughout the U.S. However, the AQS database is relatively difficult to maneuver through if the user is unfamiliar with pollutant codes and requires that the user establish a no-cost online profile to use the system. Community users may access the information contained in the NEI and AQS databases through the AirData website (http://www.epa.gov/oar/data). AirData provides annual summary statistics for all of the monitors included in AQS and facility emissions in NEI.

To construct the maps developed for the two CARE projects, pollutant concentration and cancer risk estimates were obtained from NATA while the annual monitor concentration and facility emissions summaries were obtained using AirData for each pollutant of concern, where available. In addition, the Holyoke CARE project conducted a community survey on the locations of auto body refinishing shops because the community was concerned the shop emissions were linked to children's asthma, and the Holyoke Health Center, one of the Holyoke CARE partners, provided community-specific asthma prevalence information at the census block level (Step 4). This information collected by the Holyoke CARE project was validated and used in conjunction with the concentration and facility estimates from the EPA databases to better characterize potential community exposures and risk in the Holyoke, MA community (Step 4b).

The auto body refinishing shop locations were validated using Google Earth to confirm data accuracy. Table I provides examples of the air quality hazard and pollutant groupings for the Detroit and Holyoke CARE projects. The air quality hazard and pollutant groupings included in Table 1 are not exhaustive (i.e., the emissions from point, mobile and area sources often contain multiple pollutants) and are intended to convey the primary pollutants attributed to the environmental concerns identified by the CARE projects under normal conditions.

Because the current EPA mapping tools lacked the desired features for an integrated, community mapping application (e.g., lack of a multi-pollutant framework, health-based risk-estimates, etc.), the pollutant concentration and health risk GIS maps for this study were created by the lead authors using ArcGIS 9.2 (ESRI, Inc.). The maps incorporated a combination of pollutant concentration and cancer risk estimates from NATA, information from AirData on ambient pollutant concentrations at monitored locations and facility emissions, and community-generated data (Step 5). The maps were generated using the most recent, publicly-available information for each database: 2007 AirData monitor averages (obtained from the AQS), 2002 AirData (obtained from the 2002 NEI) facility emissions, and the 2002 NATA.

The GIS maps use a color-coded shading scale (red – highest modeled concentration or risk to green – lowest modeled concentration or risk) to differentiate potential exposure levels or cancer risk estimates across census tracts for NATA estimates. The NATA website provides KMZ files to view assessment results using Google Earth. The results are displayed using a 6-point color scale from green (no risk) to dark brown (high risk: >100 in a million). The community partners did not approve of using the NATA color scale for the GIS maps generated for this study since the colors did not clearly indicate areas of high risk (i.e., multiple shades of brown can be confusing) or use an intuitive color palette (green-yellow-red).

The top 5 emitting facilities, per pollutant of interest, and the monitor locations (along with corresponding averages) reported by AirData were annotated on the maps with color-specific crossbars and color-specific triangles, respectively. The emitting facilities and monitors were included to provide spatial reference to potential exposure sources and areas where known pollutant concentrations are recorded (Step 6).

The authors worked with the community partners and the respective EPA project officers (1) to create maps for the pollutants listed in Table 1 and additional pollutants as requested by the partnership (Step 7), and (2) to tailor the maps to the partnership's needs. In addition, the CARE partners from Holyoke and Detroit provided valuable feedback on the maps to the ORD (Step 8) to inform future tool development.

4. RESULTS

Over twenty maps were developed to assist risk assessment and issue prioritization efforts undertaken by the Detroit CARE and Holyoke CARE projects. For this paper, two example maps will focus on the air quality hazard and pollutant groupings listed in Table 1.

4.1. GIS Community Maps

The Wayne County cancer risk map for benzene exposure is shown in Figure 2. The 2002 NATA cancer risk estimates are associated with exposure from pollutant inhalation, and do not address other exposure pathways [(24)]. Summary results of the 2002 NATA indicate that benzene is the most significant air toxic for which cancer risks were estimated and that on-road mobile sources (e.g., vehicles traveling on roads or highways) were the key source category for benzene [(25)]. As shown in Figure 2, the cancer risk due to benzene exposure ranges from 0 to 86 in a million with the highest risk areas located near the highways and major roads; however, this association is not true for all areas and is dependent upon the distribution of point sources, traffic

patterns and meteorology. Although NATA provides the risk estimates in numerical form at the census tract level, previous studies have shown that precision in perception of risk is enhanced by presenting risk magnitudes visually [26], and, furthermore, the Detroit CARE project found that the visual display of the information was a useful aid for explaining risk to the broader community. In addition to the risk estimates, monitor averages and the five facilities reporting the highest emissions for benzene are included on the map. In general, the mapped facilities are not associated with the potentially high cancer risk census tracks for benzene. Although there are considerable spatial uncertainties, area sources (stationary and nonroad sources that are not included in a stationary source emissions inventory because of their size or number, such as gas stations) and non-TRI facilities may be the greatest contributors to elevated pollutant levels or health risk estimates in some communities [27].

Since cancer risk estimates are only predicted for areas with long-term records linking exposure and health that is normally found only in metropolitan areas, cancer risk estimates for Hampden County, MA are not available in the 2002 NATA. However, local monitoring databases or health registries may be useful in understanding potential risk from environmental pollutants in suburban or rural communities. The diesel PM concentrations for Holyoke, MA (and surrounding neighborhoods) with local asthma incidence are displayed in Figure 3. The maximum diesel PM concentration for Holyoke, MA is 1.5 ug/m^3 with the census tracts having the highest concentrations centered in downtown Holyoke near U.S. Interstate 91. Overlaid on the diesel PM concentrations are the locations of local auto body shops and the leading 30% of census blocks with the highest number of asthma cases (n=15) obtained from the Holyoke Health Center. The number of asthma cases shown in the shaded blocks range from 73 to 211 cases. The majority of the census blocks with the highest asthma rates are located within census tracts

with higher diesel PM concentrations. The asthma cases shown in Figure 3 do not represent all occurrences of asthma within the mapped area, but only cases reported by patients seen at the Holyoke Health Center. Communities interested in mapping similar health information should contact medical care facilities in their specific study area and in surrounding areas to obtain a complete database of health outcomes.

4.2. Community Feedback

Feedback on the GIS maps was provided by the EPA project officers and community partners affiliated with the Detroit CARE and Holyoke CARE projects, and several suggestions to include in future map revisions were provided by the project representatives. Because many community residents initially seek to find known locations of interest (i.e., home, workplace, relative's home, etc.) when viewing maps, GIS maps that portray a smaller geographical area and provide more street detail, may be better suited for community use. Furthermore, the community partners suggested that the maps include other points of interest on the maps, including hospitals, health clinics, and schools, to illustrate the proximity of health care centers to areas with higher exposure risk or vulnerable populations.

In addition to the inclusion of schools, the partners from the CARE projects recommended that the maps include information on the relationship between pollutant exposure and potential health outcomes. The addition of these health-related annotations may facilitate the viewer's understanding regarding the pollutant-health outcome groupings (i.e., the effects of diesel PM on asthma incidence and exacerbation). However, many factors outside of ambient air pollution are associated with health outcomes (i.e., mold, pollen, radon, and ETS). In communicating potential health outcomes from pollutant exposures, scientists and community

leaders must give due diligence to the underlying uncertainties and known scientific gaps in the risk communication.

Lastly, the facilities identified through the NEI and TRI databases may be outdated in regard to operation (i.e., active listings may no longer be in operation) and/or business name (i.e., facilities may be listed under an older business name). Because the facility data was geocoded from addresses supplied from the databases, the facility point data needs to be verified through surveys or other measures to reduce the spatial uncertainty. The local partners from the Detroit CARE and Holyoke CARE projects advocated having maps that provide the facility information supplied by NEI, but also include notes reflecting business name changes and operational updates. The EPA's Enforcement and Compliance History Online (ECHO) database (http://www.epa-echo.gov/echo/) provides detailed information on facilities, including current operational status, inspection history and violations that can be used to supplement the data obtained from NEI.

The community partners plan to use the GIS maps in their projects to increase community awareness in relation to environmental exposure risk and to inform their risk-ranking decisions. The Holyoke CARE project will present the maps to residents and use the information to support a local diesel engine anti-idling campaign and advocate for greater oversight of local auto body refinishing shops. The Detroit CARE project plans to share the maps with residents, local collaborators, and policymakers to encourage modifications to two major transportation projects with potential to negatively impact Southwest Detroit.

4.3. Real world application for prioritization and decision-making

Communities are ultimately concerned about risk, or projected human health impacts, and what can be done to mitigate those risks. This study provides a framework to assist

communities in understanding potential risks; however, trans-disciplinary approaches are required that combine various fields including emissions characterization, dispersion modeling, human time-location activity patterns, toxicology and epidemiology to characterize the risk to humans from cumulative environmental exposures. In addition to new approaches, it is necessary to integrate the information in a consistent and comparable manner across different media such as air, water, or land, to provide communities with a comprehensive characterization of their environment. This study also highlights the need for new methods to integrate exposure and spatial modeling tools with modifying factors (e.g., social science data) for characterizing how the complex interactions between environmental stressors and modifying factors impact human exposures and risks in the community setting.

In an effort to advance the science to accurately characterize and communicate community health risk, ORD is developing the Community-Focused Exposure and Risk Screening Tool (C-FERST; http://www.epa.gov/heasd/c-ferst) [28]. C-FERST will automate the laborious process of generating maps of interest for community mapping projects such as the Detroit and Holyoke communities. C-FERST will allow users to generate maps using estimations from NATA, AirData and other databases from multimedia environmental media, and supplement these maps with local information.

The framework and results presented in this study can be used by communities to prioritize environmental concerns and develop mitigation strategies. However, the approach and maps discussed in this work are not intended to be utilized apart from knowledge on other influencing sources or behaviors. For example, there may be a community that has a high relative incidence of asthma, cancer or other health outcome that is associated with air toxics, but the community-specific maps do not reveal elevated concentrations of ambient pollution in the

affected community. In this scenario, the community may use the maps to support local efforts to access the influence of indoor environments (e.g.., pesticide use, ETS, etc.) or activities (e.g., cleaning practices, cooking methods and preferences, etc.) on residential exposures.

4.4 Discussion

In addition to the feedback provided by the community partners, the application of these databases to create community-specific GIS maps resulted in several observations by the authors. The media of concern (e.g., air, water, land) and the community attributes (e.g., size, population, and attainment status) impact the type and amount of information available to produce maps to address community environmental concerns. Several national databases exist that contain air quality statistics suitable for mapping purposes; whereas, fewer databases exist for water quality and land-related indicators. However, local environmental information is available from state agencies and regional EPA offices for communities interested in developing maps related to water and land issues. Depending on the source, even with the air quality databases, the information may vary in regard to the number of pollutants contained within the database and the spatial scale depending on the community attributes. Detroit, MI is a non-attainment area for the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS), whereas Holyoke, MA is in attainment of all the NAAQS [29]. Because Detroit is within a non-attainment area, greater emphasis is placed on generating datasets that researchers and governmental agencies can use to guide efforts to decrease pollution levels. As a result, non-attainment areas tend to have more monitoring data available and likely to have more toxics included in the NATA.

In regard to data availability, larger cities typically hold an advantage in regard to spatial mapping activities since the U.S. Census Bureau defines census tracts based upon population estimates. Census tracts typically have between 2,500 and 8,000 persons and, when first

designated, are designed to be similar with respect to demographics, such as population characteristics, economic status, and living conditions. The spatial size of census tracts varies widely depending on the local population density [30]. In large metropolitan areas, census tracts are relatively small in terms of land area because of the higher population density compared to smaller, rural areas. Based upon the results of the 2000 census, the population densities for Wayne County and Hampden County are 3,356 and 738 persons per square mile, respectively [31-32]. Accordingly, census tract-level estimates for Wayne County may convey information at the neighborhood level while census tract-level records may be an inappropriate scale to assess community exposure and risk from environmental pollution in Hampden County. Therefore, information gathered through community assessments or local monitoring initiatives is important, especially in smaller, rural areas, to properly characterize community health hazards.

Furthermore, map development using GIS software such as ArcGIS may be difficult for community groups due to cost or the unavailability trained personnel. However, there are multiple open source GIS software packages available for this type of application including MapWindow (www.mapwindow.org), MapServer (www.mapserver.org) and ArcGIS Explorer (http://www.esri.com/software/arcgis/explorer) that provide free, interactive mapping capabilities.

5. CONCLUSIONS

In order to gain an understanding of the scientifically-based information needs of communities, ORD conducted an assessment of existing EPA-developed mapping applications and environmental databases, and has partnered with two CARE projects in Detroit, Michigan and Holyoke, Massachusetts to employ these databases in a GIS mapping application to address specific information gaps identified by the partnerships. This paper presents a strategy for

developing GIS maps to assist communities in the identification and prioritization of local environmental issues, example maps developed for the Detroit CARE and Holyoke CARE projects, community feedback on the maps and implications for future community mapping projects.

Feedback received from the Detroit CARE and Holyoke CARE projects indicates that maps, such as those developed for this paper, provide useful information for communities to identify and prioritize their environmental problems. Although the maps were developed as stand-alone tools, background information should be provided to the community regarding the assumptions and models used to populate the underlying databases utilized to construct the maps. This information is pertinent to providing the proper context to understand the information communicated through the maps and for ground truthing the values displayed on the maps. Furthermore, communities that may receive the greatest benefit from such maps are those that have local expertise to assist with the interpretation of the maps and summary tables. Because most communities are primarily concerned with health risk, community leaders may be persuaded to develop cancer risk maps to avoid the time, expense or energy involved in generating the concentration maps. However, the concentration maps provide two primary benefits for communities: 1) Concentration maps ground-truth the cancer risk maps; and 2) For pollutants that do not have cancer risk maps (i.e., diesel PM, lead, etc.), concentration maps may provide qualitative information on potential cancer risks given the relationship between exposure and projected cancer risk. Therefore, communities may benefit most from environmental mapping projects when concentration maps are used in conjunction with health outcome-focused risk maps.

In addition, from a community-usability perspective, community transferability of these mapping methods may be hindered by the GIS software. The development of the maps was a complicated and time-consuming process which required sophisticated knowledge concerning the operation of the ArcGIS software. Wood [33] indicates that hands-on use of GIS, with support, provides greater benefit and empowerment of community groups when responding to local geographic issues more so than maps developed by persons or organizations outside the partnership. Communities interested in undertaking a community mapping project should seek to incorporate partners with specific skills in GIS, environmental science, and risk communication. If GIS resources are not available, communities may consider utilizing geobrowsing tools to create community-specific maps, such as World Wind (http://worldwind.arc.nasa.gov), Mappler (http://www.mappler.com) or Virtual Earth (http://www.microsoft.com/VirtualEarth).

Lastly, community maps and EPA databases, such as those developed and reviewed as part of this study, do not address community concerns related to non-chemical issues (e.g., odor, noise, etc.). Communities, in general and those involved in this study, seek guidance on assessing health risk related to exposures outside the traditional environmental areas [34]; hence, future work will include methods to develop visual tools to support the identification and assessment of non-chemical environmental issues.

DISCLAIMER

Although this work was reviewed by EPA and approved for publication, it may not necessarily reflect official Agency policy. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Table I. Examples of the air quality hazard and pollutant groupings

CARE Project	Hazard	Pollutant(s) of Concern	Cancer Risk Information Available?	Local Information Included?
Detroit/Holyoke	Diesel Trucks	Diesel PM and Elemental Carbon	N	Y - Holyoke
Detroit/Holyoke	Vehicle Exhaust	NOx and Benzene	Y - Benzene (Detroit only)	N
Detroit	major point sources	Lead and Coke Oven Emissions	Y - Coke Oven Emission	N
Holyoke	auto body shops	Nickel, Manganese, Lead, Chromium	N	Y – Auto Body Shops

Figure 1. Flow Chart of Community-focused Mapping Process

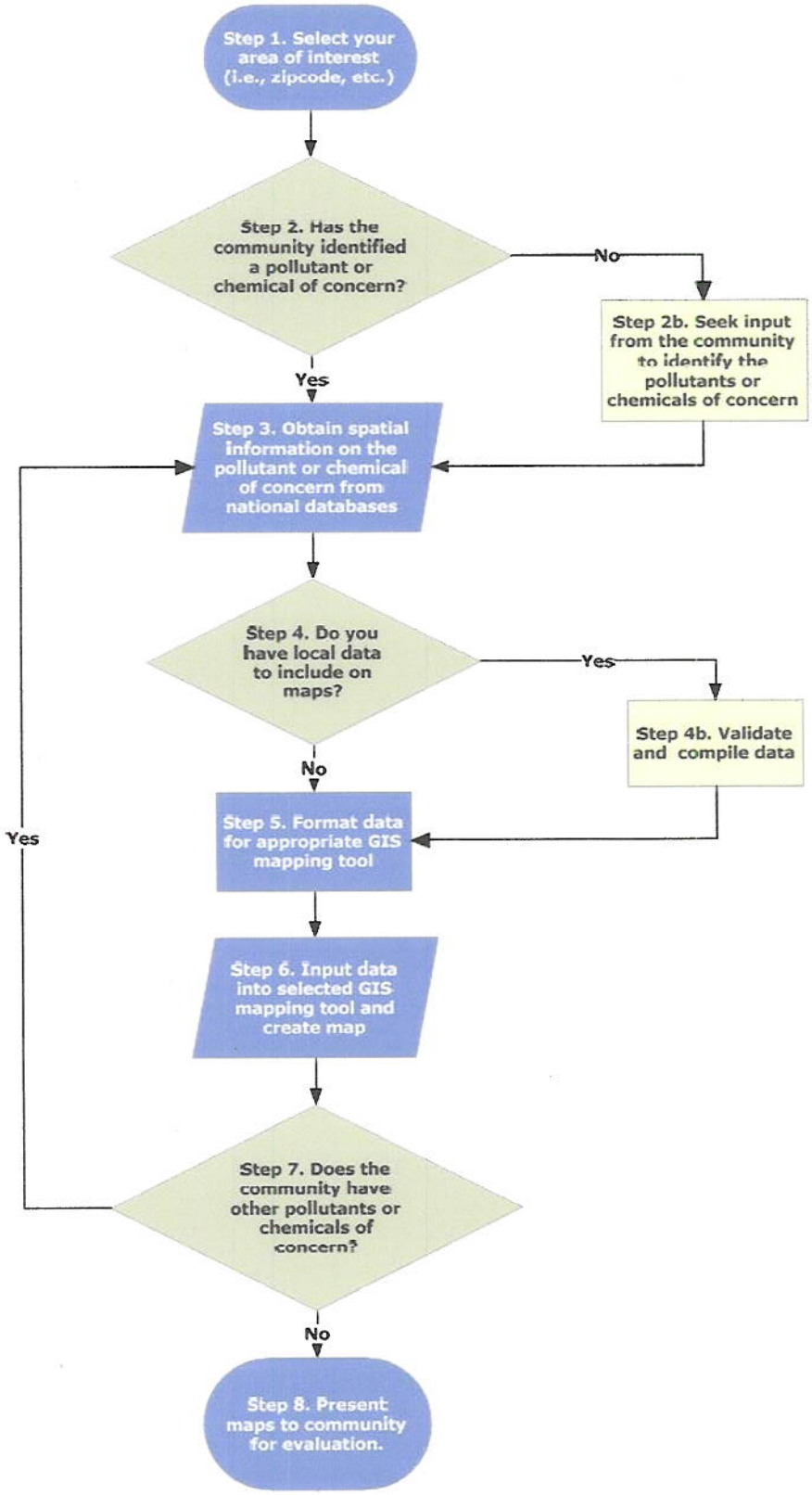
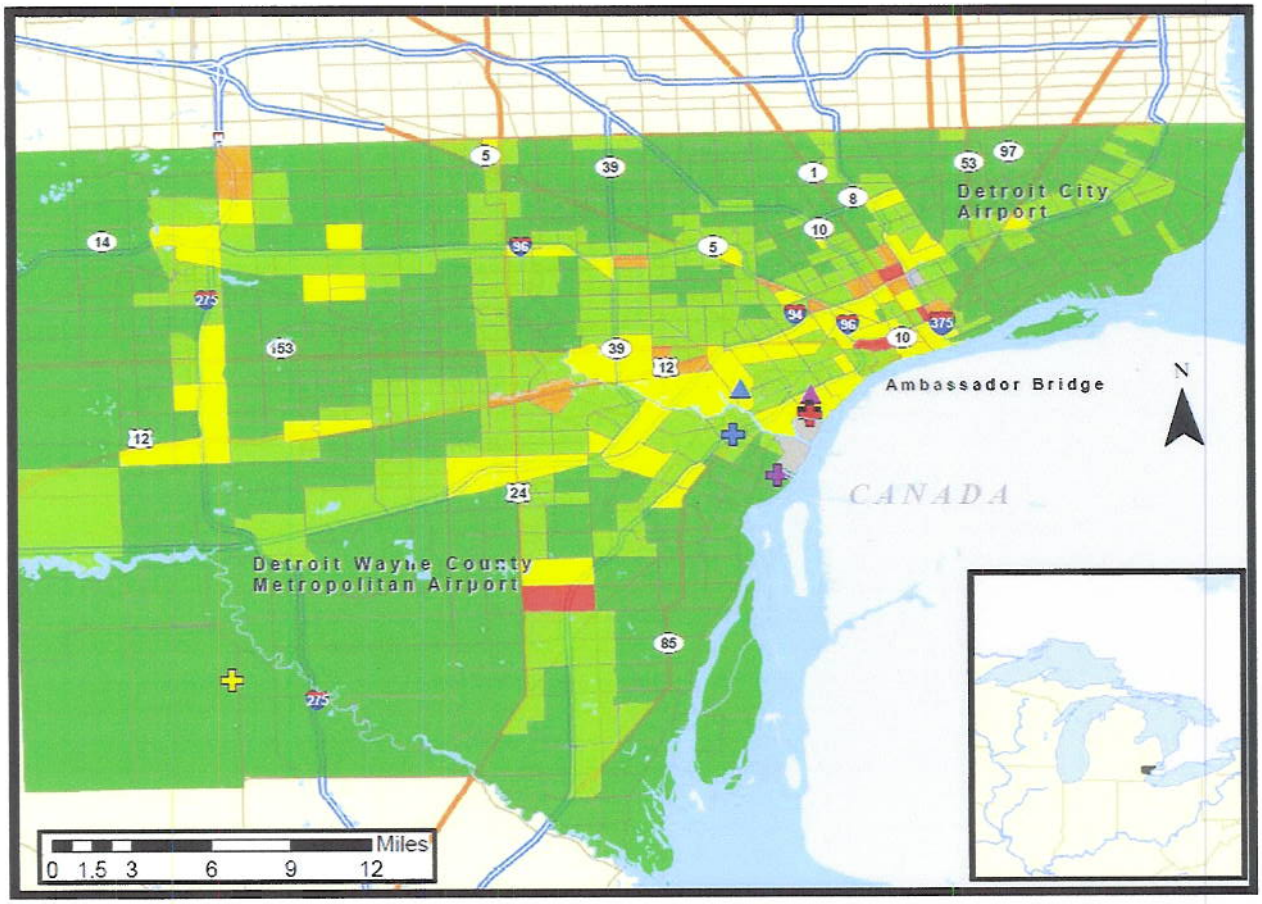


Figure 2. Cancer Risk from Benzene Exposure for Wayne County, Michigan



2002 NEI Top 5 Benzene Emitting Industries

- National Steel 56,842 lbs/yr
- Honeywell 8,919 lbs/yr
- Marathon Ashland Petroleum 8,738 lbs/yr
- Detroit Coke Plant 2,389 lbs/yr
- Judd Landfill 2,389 lbs/yr

Wayne County Monitoring Sites 2007 AirData Benzene Monitors

- Dearborn Monitor 12.00 ppbV (1.06 μg/m^3)
- Detroit Monitor 14.4 ppbV (1.28 μg/m^3)

Wayne County Census Tracts

2002 NATA Total Cancer Risk (per million)

- No Population
- 0 - 20
- 21 - 30
- 31 - 40
- 41 - 50
- 51 - 86

Sources: 2002 NATA, 2007 AirData and 2002 NEI Databases
Monitor values represent annual mean benzene concentrations

Figure 3. Diesel PM Concentrations and Census Blocks with the Highest Asthma Incidence for Holyoke, MA