

## Tools available to communities for conducting cumulative exposure and risk assessments

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This paper summarizes and assesses over 70 tools that could aid with gathering information and taking action on environmental issues related to community-based cumulative risk assessments (CBCRA). Information on tool use, as well as development and research needs, was gathered from websites, documents, and CBCRA program participants and researchers, including 25 project officers who work directly with community groups. The tools were assessed on the basis of information provided by project officers, community members, CBCRA researchers, and by case study applications. Tables summarize key environmental issues and tool features: (1) a listing of CBCRA-related environmental issues of concern to communities; (2) web-based tools that map environmental information; (3) step-by-step guidance documents; (4) databases of environmental information; (5) computer models that simulate human exposure to chemical stressors. All tools described here are publicly available, with the focus being on tools developed by the US Environmental Protection Agency. These tables provide sources of information to promote risk identification and prioritization beyond risk perception approaches, and could be used by CBCRA participants and researchers. The purpose of this overview is twofold: (1) To present a comprehensive, though not exhaustive, summary of numerous tools that could aid with performing CBCRAs; and (2) To use this toolset as a sample of the current state of CBCRA tools to critically examine their utility and guide research for the development of new and improved tools.

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### Introduction

Regulatory agencies involved with environmental hazard identification, classification and health effects have begun to expand beyond the single-chemical, single-pathway research paradigm to include human exposures to mixtures of chemicals that occur through multiple media (e.g., air, water, soil, diet) and routes (e.g., inhalation, ingestion, dermal) (NRC, 1993, 1994; NAPA, 1995; PCCRARM, 1997; USEPA, 2000, 2003). These cumulative exposure and risk assessments attempt to quantify the health risks associated with exposure to multiple chemicals in multiple media through multiple pathways (Menzie et al., 2007; Ryan et al., 2007; Sexton and Hattis, 2007; deFur et al., 2007; NAS, 2008; USEPA, 2008a) as opposed to a single chemical and pathway. Chemical mixtures may reflect real-world

exposure scenarios encountered by individual communities, which are generally represented by a geographic area on the order of several square miles, and may include a host of pollutant types and sources.

Community-based risk assessments have been gaining momentum as community groups become involved in identifying, prioritizing, and mitigating their environmental concerns (Kinney et al., 2000; Arquette et al., 2002; O’Fallon and Deary, 2002; Perera et al., 2002; Corburn, 2002a; NEJAC, 2004; Schell et al., 2005), many of which are pollutant-based. In these types of programs, communities play a central role in defining problems and required data, supplying local knowledge, and interpreting results in the context of local understanding and decision-making. Researchers and agencies may conduct exposure and risk assessments through community case studies, addressing the community pollutants, and working directly with community members (Clinton, 1994; O’Fallon and Deary, 2002; USEPA, 2005, 2007; Denholm and Martin, 2008).

Community-based cumulative risk assessments (CBCRA) combine principles of cumulative exposure assessments with community-based profiles and participation. “Profiles” in this sense refer to the pollutant types, sources, and exposure

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patterns for individuals within a given community. Challenges for initiating and performing a CBCRA include information gathering, risk prioritization, and mitigation (NCEA, 2007). CBCRAs may be led by community groups themselves, or by researchers interested in conducting real-world exposure and risk assessments, which may include developing methods that can be applied across communities.

This paper focuses on a set of publicly available tools that address community-related pollutants at relevant spatial scales. The purpose of this overview is twofold: (1) to present a comprehensive, though not exhaustive, summary of numerous tools that could aid with performing CBCRAs; and (2) to use this toolset as a sample of the current state of CBCRA tools to critically examine their utility and guide research for the development of new and improved tools. Tables presented here summarize environmental issues identified by communities, web-based geographic information systems (GIS) mapping tools, community-related guidance documents, online databases organized by environmental media, and human exposure computer models. For reasons described below, the focus is on tools developed by the US Environmental Protection Agency (EPA), though other tools are also acknowledged.

## Methods

The US EPA has initiated a research program to develop exposure tools for advancing the science and understanding of cumulative risk to communities and individuals, hereafter called the Cumulative Communities Research Program (CCRP), which is described in detail by Zartarian and Schultz (2009). *Tool* is a broadly defined umbrella term that may include information, strategies, fact sheets, web portals, exposure models, databases, sampling methods, or GIS. The universe of tools covered by this definition is vast. Without some limitation criteria, summarizing the available tools, presenting an inter-comparison, and evaluating their effectiveness would be too broad to precisely address the second main goal of this paper, which is a critical assessment of current tools to inform future tool development.

We therefore focused on publicly available tools developed by the US EPA related to identifying, prioritizing, and mitigating environmental hazards. Over 75 tools were summarized and assessed. EPA tools undergo a thorough review before becoming publicly available. Several non-EPA tools that are in use and include verified methodologies are presented here in the text, but for consistency are not included in the tables. Information for the summary tables was gathered primarily from three sources: (1) EPA documents, (2) EPA websites, and (3) collaborations or conversations with people or groups in the EPA and other regulatory agencies who have worked on community-related or cumulative risk assessments.

This section presents the methods and sources used to identify tools to populate the tables. It also describes the inclusion criteria for each table. Finally, it includes a general description of how the tools were assessed.

### *Focus on Identification, Prioritization, and Mitigation*

The EPA Community Action for a Renewed Environment (CARE; [www.epa.gov/care](http://www.epa.gov/care)) program provides funding and technical assistance to community groups across the country to address their environmental concerns. CARE project officers are EPA representatives who work in regional offices and provide technical assistance to CARE grantees within their geographic area. The CCRP works closely with CARE representatives. We conducted a phone survey of 25 project officers and gathered information from their quarterly reports. Survey responses elucidated many things: (1) lists of environmental issues that community groups (CARE grantees) had identified; (2) gaps in information or resources; (3) which tools were being used by communities; and (4) key personnel or groups who had contributed. Results from the survey were presented at an international conference and will be published separately (Barzyk et al., 2007).

Project officers stated that four of the most challenging steps facing the community groups included: (1) identifying actual pollutant sources of health risks; (2) gathering information about them; (3) ranking or prioritizing them in terms of health risks or available resources, respectively; and (4) quantifying the effects of mitigation. This paper, therefore, focuses on tools that aid with these challenges.

The primary motivation and goal for this paper is to provide a summary of publicly available tools that could be used by community groups and professionals working on CBCRAs, and to empower them to overcome the challenges listed above. Through telephone interviews and quarterly reports, we learned that the range of environmental issues was vast, and include chemical stressors such as diesel emissions and lead paint, as well as non-chemical stressors such as unsafe crosswalks or noise pollution (Barzyk et al., 2007). Currently, this research focuses on chemical-based stressors and exposures.

### *Identifying Specific Tools*

After developing the general categories of exposure tools, the tools themselves needed to be identified to populate the tables. We conducted an extensive search of EPA and other websites and solicited input from groups familiar with community or cumulative risk assessments. These groups included CARE project and administrative officers, the EPA Community-Based Technical Support Forum (EPA groups and individuals who collaborate on development of CBCRA risk assessment or management strategies), individuals and groups in program and regional offices, and others engaged in CBCRA research, tools, and applications. The goal was to

understand what tools have been developed, what has worked, and what is needed to better assist communities.

To focus the scope of each of the summary tables, we developed clearly defined inclusion criteria. For Table 1, Environmental Issues Related to Communities, only issues associated with chemical stressors were included. Web-based GIS Tools (Table 2) required a visual mapping component for a given spatial domain. Guidance Documents (Table 3) must provide a suggested approach, generally step-by-step, to either identify or reduce human health risks in a community. Databases (Table 4) must be publicly available and capable of being queried, or included in the EPA Envirofacts Warehouse tool, which draws from a number of databases to produce GIS maps. Exposure Models (Table 5) are required to focus on the contact between a chemical and the external surface (e.g., skin, nostrils, mouth) of the person.

The CARE Resource Guide (USEPA, 2008b) lists a number of tools useful for organizing and maintaining community partnerships. It also lists several technical tools with brief descriptions. The combination of the Resource Guide and the tools listed here present a fairly comprehensive set of tools for aiding CBCRAs, from forming a partnership to addressing environmental health risks. The CARE program also includes a ten-step “roadmap” to help communities form partnerships and work toward a healthier community and environment (CARE, 2008).

### Assessing the Tools

With the perspectives provided by the telephone interviews of CARE project officers, as well as those provided through active communication with CBCRA researchers, we were able to assess many of the benefits and limitations of each of the tools, as well as the broader tool categories (e.g., GIS or guidance documents). This information allowed the CCRP to assess the tools from the users’ perspectives.

As each web-based GIS and database tool was identified, community-specific information, such as zip code, was entered to provide output. Each tool was assessed on the basis of a number of criteria: (1) ease of use; (2) relevance of information; (3) output type (e.g., maps or lists); (4) information to interpret results; and (5) comprehensiveness (e.g., breadth and depth of information). Guidance documents were reviewed to assess their utility on the basis of CBCRA perspectives. We conferred with exposure model developers and experts to gather the most relevant information about them as related to us by CBCRA researchers. The CCRP also conducted an extensive search of the literature to determine whether these tools were being used in published studies; we found very few examples of this.

The Results section focuses on the tables themselves, and the Discussion section presents our analysis of the intersection between available tools and CBCRA needs, and a proposed course for future tool development.

**Table 1.** Examples of environmental issues related to chemical stressors identified by selected EPA reports and residential community projects

Examples of chemical-related environmental issues	
Accidental releases – oil spills	Industrial solid waste sites
Accidental releases – toxics	Industrial waste discharges to surface waters
Agriculture	Integrated pest management/pesticides
Airport	Land use/redevelopment/smart growth
Air quality	Lead
Mobile source pollution (highways)	Mercury
Air quality – point source emissions	Methamphetamine labs
Ambient air pollutants	Mining waste
Arsenic in soil	Mold
Asbestos	Municipal solid waste sites
Asthma	Municipal waste discharge to surface waters
Autobody shops/recyclers	New toxic chemicals
Brownfields	Non-hazardous waste sites – industrial
Burning	Non-hazardous waste sites – municipal
Children’s health	Non-point source discharge to surface water
Coal dust	Odor and noise pollution
Consumer exposure to chemicals	Particulate matter (fine)
Contaminated sludge	Pesticide application
Creosote	Pesticide residue on foods
Criteria air pollutants	Physical degradation of water and wetlands
Diesel exhaust	Point sources – major other than landfills
Direct point source discharges to water	Printers
Dredging/PCBs	Radiation (other than indoor radon)
Drinking water	Radon
<i>E. Coli</i> at beaches	School buses (including diesel)
Environmental tobacco smoke	Schools/hazardous waste
Energy conservation	Soil – unlined sumps
Fish consumption	Solid waste disposal (bulky items, landfills)
Groundwater contamination	Recycling
Hazardous/toxic air pollutants	Storage tank releases
Hazardous waste/pharmaceuticals	Super-emitting cars
Hazardous waste sites – active	Ozone depletion (UV exposure)
Hazardous waste sites – inactive	Uranium mines
Hazardous waste sites – abandoned/superfund	Vector diseases
Healthy homes (cleaning products, allergens)	Water quality – wastewater/sewage
Indirect point source discharges to water	Water quality – stormwater runoff
Indoor pollution	Chemical exposures (industry and agriculture)
Indoor vapor intrusion	Worker health

**Table 2.** EPA web-based GIS tools that include visual mapping of information contained in EPA databases.

Tool and web address	Mapping features	Databases accessed
EnviroMapper Storefront www.epa.gov/enviro/html/em (includes next 10 tools)	Website including the 10 tools listed directly below: WME, Regulated Facilities, EJGAT, Brownfields, NPL, TRI, Surface Water Features, Waste Management Facilities, Pesticide Use Limitations, and Cleanups in My Community	Envirofacts Warehouse (see Table 4; Databases)
Window to my Environment www.epa.gov/enviro/wme	Provides a range of federal, state and local information, including regulated facilities, monitoring sites and watershed information, with an interactive map and links to information	Envirofacts Warehouse
EPA-Regulated Facilities www.epa.gov/enviro/html/em	EPA-regulated facilities with interactive map to display facility name and its multisystem report	Envirofacts Warehouse
Environmental Justice Geographic Assessment Tool (EJGAT) www.epa.gov/compliance/whereyoulive/ejtool.html	Environmental information such as regulated facilities, air & water monitors, as well as demographic information such as persons per square mile, per capita income, and % below poverty line	Envirofacts Warehouse
Brownfields Grant Types and Properties www.epa.gov/enviro/html/em	Interactive map to locate, display, and query brownfield grant types	Brownfields Database
Superfund National Priorities List (NPL) Sites www.epa.gov/enviro/html/em	Interactive maps and aerial photography to display and query NPL sites, sites or releases that may require remedial action	National Priorities List
Toxics Release Inventory (TRI) Site Location www.epa.gov/enviro/html/em	Maps facilities listed in the TRI, which houses emissions information organized by facility and/or chemical	Toxics Release Inventory
Surface Water Features www.epa.gov/enviro/html/em	Maps features such as impaired and assessed waters, sewage no discharge zones, non-point source projects, water quality stations, and water facilities	Multiple databases that link geographic and water quality information. Utilizes National Hydrography Dataset EPA-regulated facilities database
Waste Management Facility Siting Tool www.epa.gov/enviro/html/em	Maps of waste management facilities as well as other regulated facilities, such as superfund, toxic releases, water discharge, air emissions, and others	Based on 9th District Court Order
Pesticide Use Limitations www.epa.gov/enviro/html/em/index2.html	Displays information about restrictions on using certain pesticides, such as use near source waters	
Cleanups in My Community www.epa.gov/enviro/html/em	Displays information on federally regulated cleanups, including their planned or current status, and provides link to multisystems reports of the cleanup sites	Superfund National Priorities List, RCRA Corrective Action, Brownfields Properties
TRI-NATA Explorer www.epa.gov/nata	In development; scheduled for public online availability in Fall 2008. Maps include air toxic concentrations and human health risks (from NATA), as well as emissions information from TRI	National Air Toxics Assessment (NATA) and Toxic Release Inventory (TRI)
TRI Explorer www.epa.gov/triexplorer	Generates tabular data from TRI by facility or chemical for a specified region, including total or chemical-specific air emissions, surface water discharges, and on- or off-site disposals	Toxics Release Inventory
National Priorities List Mapping Tool www.epa.gov/superfund/sites/npl/npl.htm	Interactive maps of NPL sites by EPA Region, which identifies sites or other releases that appear to warrant remedial actions	National Priority Site Listings, CERCLIS
AirNow http://airnow.gov	Website developed by EPA, NOAA, NPS, tribal, state, and local agencies to provide public access to national air quality information including the Air Quality Index (AQI)	Conditions for ozone and particle pollution reported by EPA, NOAA, NPS, news media, tribal, state, and local agencies
Regional Air Impact Modeling Initiative (RAIMI) www.epa.gov/earth1r6/gen/raimi/index.htm	Evaluates potential for health impacts from multiple sources at the community level; utilizes air models and toxicity assessments for multiple sources to model dispersion, exposure and risk, and outputs results to GIS; relatively technical tool compared to others in this table	Health Effects Assessment Summary Tables (HEAST), Integrated risk information system (IRIS), National Toxics Inventory (NTI), Toxic Release Inventory (TRI), Aerometric Information Retrieval System (AIRS), RCRA Information System, TNRCC Point-Source Database (PSDB), New Source Review Permit Files, Facility files and records, permit applications

**Table 2.** *Continued*

Tool and web address	Mapping features	Databases accessed
Internet Geographical Exposure Modeling System (IGEMS) <a href="http://www.epa.gov/oppt/exposure/pubs/gems.htm">www.epa.gov/oppt/exposure/pubs/gems.htm</a>	Currently in development. Requires extensive inputs. Multiple models incorporated into a relatively easy-to-use interface compared to stand-alone counterparts, with interactive selection features and GIS outputs; includes fate and transport models for ambient air, surface and ground water, and soil	Models include ISCLT, ISCST, SESOIL, AT123D, PROUTE, TRIWATER, and TRIAIR; census data
National Hydrography Dataset Reach Indexing Tool (NHD-RIT) <a href="http://www.epa.gov/owow/monitoring/georef/RIT.htm">www.epa.gov/owow/monitoring/georef/RIT.htm</a>	Interactive GIS application that allows users to georeference surface water data from the NHD	National Hydrography Dataset
Web-Based Reach Indexing for WATERS <a href="http://www.epa.gov/waters/webrit">www.epa.gov/waters/webrit</a>	Web-based mapping tool that allows users to provide and update location-specific data for a variety of water programs	WATERS (Watershed Assessment, Tracking and Environmental Results) connects several independent databases related to water quality
Surf your watershed <a href="http://cfpub.epa.gov/surf/locate/index.cfm">http://cfpub.epa.gov/surf/locate/index.cfm</a>	Watershed information for the specified geographic area, including citizen-based groups involved in the watershed, impaired waters, geologic information, and counties affected	United States Geological Survey (USGS), Total Maximum Daily Loads Reports

**Table 3.** EPA guidance documents listed with their intended applications and audiences

Tool and web address	Application	Audience
Air Toxics Risk Assessment Reference Library (ATRA) <a href="http://www.epa.gov/ttn/fera/risk_atra_main.html">www.epa.gov/ttn/fera/risk_atra_main.html</a>	Presents principles of risk-based assessments for air toxics, how to apply them in different settings, and strategies for reducing risk at a local level	Users interested in conducting air toxic analyses at the facility- and community-scale
Air Quality Criteria for Lead <a href="http://oaspub.epa.gov/eims/xmlreport.display?deid=32647&amp;z_chk=2629">http://oaspub.epa.gov/eims/xmlreport.display?deid=32647&amp;z_chk=2629</a>	Assesses health and welfare effects associated with exposure to various concentrations of lead in ambient air; includes chapters on chemistry and physics of lead, atmospheric chemistry and dispersion, and health effects	Researchers involved with work pertaining to the Clean Air Act
Asbestos Project Plan <a href="http://www.epa.gov/asbestos/pubs/asbestosprojectplan.pdf">www.epa.gov/asbestos/pubs/asbestosprojectplan.pdf</a>	Framework for coordinated EPA-wide approach to identify, evaluate and reduce human health risks to asbestos exposure	EPA researchers involved with asbestos-related exposure and health assessments
A Citizen's Guide to Radon <a href="http://www.epa.gov/radon/pdfs/citizensguide.pdf">www.epa.gov/radon/pdfs/citizensguide.pdf</a>	Information and EPA-suggested guidelines for ways to reduce human exposure to radon in homes	Homeowners, local business owners, or anyone potentially exposed to radon
Community Air Screening How-To Manual <a href="http://www.epa.gov/oppt/cahp/pubs/howto.htm">www.epa.gov/oppt/cahp/pubs/howto.htm</a>	Step-by-step guide to help communities identify sources of outdoor air pollution, conduct risk-based screening analysis to set priorities, and develop recommendations for taking action	Community groups and residents concerned about improving outdoor air quality
Community-Based Environmental Protection: A resource book for protecting ecosystems and communities <a href="http://www.epa.gov/CARE/library/howto.pdf">www.epa.gov/CARE/library/howto.pdf</a>	Guidance and case study examples about the benefits of a healthy ecosystem to a community, and how recreational, economic and other activities affect the quality of the ecosystem	Community groups interested in ecosystem protection and its potential benefits
Evaluating Exposure to Toxic Air Pollutants: A citizen's guide <a href="http://epa.gov/ttn/atw/3_90_023.html">http://epa.gov/ttn/atw/3_90_023.html</a>	Basic information on the processes of exposure assessments related to toxic air pollutants	Community groups interesting in conducted an exposure assessment relating to toxic air pollutants
Framework For Cumulative Risk Assessment <a href="http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54944">http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54944</a>	Provides a flexible structure for conducting and evaluating cumulative risk assessment and for addressing scientific issues related to cumulative risk	Users interested in conducting or evaluating cumulative risk assessments
A Guidebook for Explaining Environmental Regulations to Small Businesses <a href="http://www.epa.gov/ttn/atw/explain.pdf">www.epa.gov/ttn/atw/explain.pdf</a>	Materials to explain environmental standards and rules to small businesses, and presents guidelines on how to explain technical information in layman's terms	Small business owners
Household Hazardous Waste Management: A manual for one-day community collection programs <a href="http://www.epa.gov/epaoswer/non-hw/househd/hhw/cov_toc.pdf">www.epa.gov/epaoswer/non-hw/househd/hhw/cov_toc.pdf</a>	Designed to help communities plan and operate a successful household hazardous waste collection program	Community leaders and household hazardous waste collection program organizers

**Table 3.** *Continued*

Tool and web address	Application	Audience
Naturally Occurring Asbestos: Approaches for Reducing Exposure <a href="http://www.epa.gov/superfund/health/contaminants/asbestos/noa_factsheet.pdf">www.epa.gov/superfund/health/contaminants/asbestos/noa_factsheet.pdf</a>	Overview of approaches for reducing exposure to naturally occurring asbestos	State and local government officials, project managers and environmental professionals
RCRA In Focus Series (RIF) <a href="http://www.epa.gov/epaoswer/hazwaste/id/infocus/index.htm">www.epa.gov/epaoswer/hazwaste/id/infocus/index.htm</a>	Overview of the Resource Conservation and Recovery Act (RCRA) regulations affecting specific industry sources, and a guide to small businesses by relating information focused on recycling and pollution prevention	Business owners and users interested in industry-specific source regulations relating to RCRA
Reducing Air Toxics in Your Community <a href="http://www.epa.gov/ttn/atw/urban/brochurevertical_2004.pdf">www.epa.gov/ttn/atw/urban/brochurevertical_2004.pdf</a>	Guidance on simple ways to reduce air toxics in a community, and information on EPA programs designed to reduce air toxics	Local community groups, local governments, area residents
Risk Assessment Guidance for Superfund (RAGS) <a href="http://www.epa.gov/oswer/riskassessment/ragsa/index.htm">www.epa.gov/oswer/riskassessment/ragsa/index.htm</a>	Guidance on the human health evaluation activities conducted during the baseline risk assessment, which can be used to determine whether an additional response is necessary at the site	Users familiar with the Superfund program interested in conducting a baseline risk assessment
Risk Assessment Guidelines <a href="http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=55907">http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=55907</a>	Recommends principles and procedures to guide to assess risks from chemicals or other agents in the environment, and inform decision makers and the public about these procedures	EPA scientists, academic community, local governments and public health officials
Superfund Community Involvement Toolkit <a href="http://www.epa.gov/superfund/community/toolkit.htm">www.epa.gov/superfund/community/toolkit.htm</a>	Promotes successful community participation in the Superfund process, and provides information, sample documents, and suggestions for implementing community involvement activities	Superfund site teams, scientists, and community groups involved in the Superfund process
Watershed Approach Framework <a href="http://www.epa.gov/owow/watershed/framework/">www.epa.gov/owow/watershed/framework/</a>	An explanation of the guiding principles for the EPA watershed approach, as well as their implementation and benefits	Local community groups and governments, and area residents interested in protecting watershed

**Table 4.** EPA databases for environmental information sorted by media

Database and web address	Content	Updates
<i>Multimedia</i>		
Envirofacts Data Warehouse <a href="http://www.epa.gov/enviro/">www.epa.gov/enviro/</a>	Provides access to several EPA databases on environmental activities affecting air, water, and land, including Envirofacts AIRS Facility Subsystem (EF AIRS/AFS), Brownfields Management System (BMS), Biennial Reporting (BR), Comprehensive Environmental Response, Compensation & Liability Information System (CERCLIS), Facility Registry System (FRS), RadNet, Grants Information & Control System (GICS), Information Collection Rule (ICR) data, Locational Reference Tables (LRT), Permit Compliance System (PCS), Resource Conservation and Recovery Act Information (RCRAInfo), Safe Drinking Water Information System (SDWIS), Toxics Release Inventory (TRI)	Each database updated separately
Envirofacts Master Chemical Integrator (EMCI) <a href="http://www.epa.gov/enviro/html/emci">www.epa.gov/enviro/html/emci</a>	Identifies chemicals in the toxic release inventory (TRI), Aerometric Information Retrieval System (AIRS), Permit Compliance System (PCS), and Resource Conservation and Recovery Act Information (RCRAInfo)	Databases updated monthly to annually
Toxic Release Inventory (TRI) <a href="http://www.epa.gov/tri">http://www.epa.gov/tri</a>	Waste management activities reported by industry groups and federal facilities	Annually
Integrated Risk Information System (IRIS) <a href="http://www.epa.gov/iris">www.epa.gov/iris</a>	Toxicity data on chemical substances and pollutants	Annually
ECOTOX <a href="http://www.epa.gov/ecotox">www.epa.gov/ecotox</a>	Chemical toxicity data for aquatic life, terrestrial plants, wildlife	N/A
<i>Air Pollutants</i>		
National-Scale Air Toxics Assessment (NATA) <a href="http://www.epa.gov/ttn/atw/nata">www.epa.gov/ttn/atw/nata</a>	Risk Assessment of 177 toxic air pollutants nationwide, includes estimates of ambient concentrations and exposure, as well as risk characterization	1996; 1999
National Emissions Inventory (NEI) (formerly known as National Toxics Inventory NTI) <a href="http://www.epa.gov/ttn/chief/net">www.epa.gov/ttn/chief/net</a>	Information about sources that emit hazardous air pollutants and criteria air pollutants and their precursors	Every three years

**Table 4.** *Continued*

Database and web address	Content	Updates
Air Quality System (AQS) <a href="http://www.epa.gov/air/data">www.epa.gov/air/data</a>	EPA repository of ambient air quality data from 5000 air monitors with data collected by state, local and tribal agencies	Quarterly
AIRS/AFS: Aerometric Information Retrieval System/ AIRS Facility Subsystem <a href="http://earth1.epa.gov/enviro/html/airs">http://earth1.epa.gov/enviro/html/airs</a>	Computer-based repository for information about air pollution from stationary sources	Monthly
Clean Air Markets Data <a href="http://camdataandmaps.epa.gov/gdm">http://camdataandmaps.epa.gov/gdm</a>	Web-based interface to view unit, facility, emissions, and allowance data collected as part of EPA emissions trading programs	Hourly
CASTNET <a href="http://www.epa.gov/castnet">www.epa.gov/castnet</a>	Atmospheric data on the dry deposition component of total acid deposition, ground-level ozone and other forms of atmospheric pollution; 80 monitoring stations nationwide measure weekly average concentrations of acid deposition, hourly concentrations of ambient ozone levels, and meteorological conditions required for calculating dry deposition rates	Hourly
<i>Radiation</i>		
Environmental Radiation Data (RadNet) <a href="http://www.epa.gov/enviro/html/erams">www.epa.gov/enviro/html/erams</a>	National radiation data from air, precipitation, drinking water, and milk samples from a national network of more than 200 monitoring stations	NA
UV Index <a href="http://epa.gov/sunwise/uvindex.html">http://epa.gov/sunwise/uvindex.html</a>	Solar ultraviolet radiation data from the UV Net database (21 monitoring sites nationally)	NA
<i>Water</i>		
Safe Drinking Water Information System (SDWIS) <a href="http://www.epa.gov/enviro/html/sdwis">www.epa.gov/enviro/html/sdwis</a>	Reports submitted by states and regions in conformance with the Safe Drinking Water Act	Quarterly
PCS: Permit Compliance System <a href="http://www.epa.gov/enviro/html/pcs">www.epa.gov/enviro/html/pcs</a>	Information on companies which have been issued permits to discharge waste water into rivers	Monthly
National Pollutant Discharge Elimination System (NPDES) <a href="http://cfpub.epa.gov/npdes">http://cfpub.epa.gov/npdes</a>	Facilities that are point sources of water pollution	NA
STORET Data Warehouse <a href="http://www.epa.gov/storet">www.epa.gov/storet</a>	Biological, chemical, and physical measurements of surface and ground water traits from sites monitored by federal, state and local agencies, tribes, volunteer groups, academics, and others	Monthly
<i>Hazardous Waste</i>		
Brownfields Management System (BMS) <a href="http://www.epa.gov/enviro/html/bms">www.epa.gov/enviro/html/bms</a>	Data on contaminated properties under the EPA Office of Solid Waste Emergency Response Brownfields program	Monthly
RCRAInfo <a href="http://www.epa.gov/enviro/html/rcris">www.epa.gov/enviro/html/rcris</a>	Information about regulated hazardous waste treatment, storage, and disposal facilities, which replaces the National Biennial Hazardous Waste Report (BR) and the Resource Conservation and Recovery Information System (RCRIS)	Monthly extracts
Comprehensive Environmental Response, Compensation & Liability Information System (CIRCLIS Database) <a href="http://www.epa.gov/superfund/sites/cursites">www.epa.gov/superfund/sites/cursites</a>	Envirofacts database of Superfund site names, locations, and remedial actions	Monthly
<i>Compliance Data</i>		
Integrated Data for Enforcement Analysis (IDEA) IDEA search engine has two different Web interfaces available to users: OTIS (for government access) and ECHO (for public access)	Environmental performance data on EPA-regulated facilities that maintains copies of EPA air, water, hazardous waste, and enforcement source data systems	Monthly
Enforcement & Compliance History Online (ECHO) <a href="http://www.epa-echo.gov/echo">www.epa-echo.gov/echo</a>	Compliance and violation records for air, water, and hazardous waste facilities	Monthly

**Table 4.** *Continued*

Database and web address	Content	Updates
Locational Reference Tables (LRT) <a href="http://www.epa.gov/enviro/html/locational/lrt">www.epa.gov/enviro/html/locational/lrt</a>	Locational information for EPA-regulated facilities in Envirofacts	Monthly
Facility Registry System (FRS) <a href="http://www.epa.gov/frs">www.epa.gov/frs</a>	Internet access to an integrated source of comprehensive (air, water, and waste) environmental information about facilities, sites or places, that includes information from the EPA Central Data Exchange registrations and data management personnel, state master records, and EPA databases	Nightly
Integrated Compliance Information System (ICIS) <a href="http://www.epa.gov/compliance/data/systems/modernization/index.html">www.epa.gov/compliance/data/systems/modernization/index.html</a>	Integrated enforcement and compliance information on facilities from all EPA Enforcement Cases and EPA Supplemental Environmental Projects (SEPs) covering all environmental media	Real-time data entry and retrieval
<i>Other</i>		
Environmental Information Management System (EIMS) <a href="http://www.epa.gov/eims">www.epa.gov/eims</a>	Library of projects, data sets, models, and documents related to the Regional Vulnerability Assessment (ReVA) program	NA
Grants Information and Control System (GICS) <a href="http://www.epa.gov/enviro/html/gics">www.epa.gov/enviro/html/gics</a>	Contains information about EPA-awarded grants	Bi-weekly
VendInfo <a href="http://es.epa.gov/vendors/">http://es.epa.gov/vendors/</a>	Listings of pollution prevention equipment, products and services from company and technology listings	User-driven

## Results

This section presents an overview of the information included in each of the tables. The subsections address each table separately, and include details describing the tool categories, examples, and general observations. Table 1 is slightly different from the others in that, instead of tools, it lists over 70 potential environmental hazards identified through various community-related sources. Table 2 lists a variety of web-based GIS tools that map information from environmental databases at relevant spatial scales. Table 3 lists guidance documents that generally provide step-by-step instructions about addressing environmental hazards. Table 4 presents databases of measurements and information that are publicly available online. Exposure models that could potentially be used in a CBCRA are listed in Table 5. Measurement test kits that are available to the public are also a useful tool, and are listed and addressed in a separate publication (Medina-Vera et al., 2009). Relevant non-EPA tools are discussed in their respective table section.

### *Chemical-Related Stressors of Concern to Communities*

Table 1 lists a broad range of chemical-related stressors that could potentially affect human health and that were identified by communities and community-related publications as being priority concerns. Three EPA reports (USEPA, 1987, 1990, 1993), three CARE program documents, three EPA Regional assessments, and the 1999 National Air Toxics Assessment (NATA, 1999) were used as resources to compile this list. The chemical stressors are typically found within the air, water, or soil media, but some are related to indoor sources, radiation, and diet.

The top five issues based on the number of reports that identified them were diesel exhaust, drinking water, lead, fine particulate matter, and radon. The reports categorized stressors on the basis of a relative (e.g., high, medium, low) comparison, a numerical (1 = high, 26 = low) ranking, or a simple statement of importance, such as a non-ranked list of stressors to consider. We maintained the original language of the reports, even though some stressors are related, such as pesticide application and pesticide residue.

Table 1 could be used as a reference to initially identify community environmental hazards. Cumulative exposure and risk assessments may also consider non-chemical stressors, such as noise pollution, socioeconomic status, stress, or dilapidated housing (Hood, 2005; Zartarian and Schultz, 2009). These types of stressors are not included in this paper, but the National Environmental Justice Advisory Council (2004) provides a comprehensive discussion of non-chemical stressors relevant to cumulative risk in communities.

Each community may have its own unique characteristics and environmental hazards not found in other communities. Emerging issues that have not yet been well documented may need to be considered, such as polychlorinated biphenyls in window caulk in old schools and buildings (Herrick et al., 2004), and lead in artificial turf (NJDHSS, 2008). Community-specific information may be found at other organizations and agencies, such as local health departments, EPA regional offices, the Center for Disease Control and Prevention, the National Institute of Environmental Health Sciences, and the American Public Health Association.



**Table 5.** EPA-developed exposure models.

Model	Objective	Inputs	Outputs	Availability
Total Risk Integrated Methodology (Exposure-event module)/Air Pollutants Exposure Model (TRIM.Expo-APEX)	Inhalation exposure for census tract or larger area	Hourly air pollution concentrations at location, max daily temperature	Air pollutant exposure	<a href="http://www.epa.gov/ttnmain1/fera/human_apex.html">http://www.epa.gov/ttnmain1/fera/human_apex.html</a>
Human Exposure Model-3 (HEM-3)	Inhalation exposure for census tract or larger area	Emission rates, emission source configurations and locations	Outdoor air concentration, air pollutant exposure, cancer risk (inhalation), Target Organ-Specific Hazard Index (inhalation)	<a href="http://www.epa.gov/ttn/fera/hem_download.html">http://www.epa.gov/ttn/fera/hem_download.html</a>
Human Exposure Model – Screening Level Analysis (HEM-Screen)	Screening-level exposure for census block or larger area	Emission rates, emission source locations, pollutant unit risk factors	Outdoor air concentration, air pollutant exposure, cancer risk (inhalation), Target Organ-Specific Hazard Index (inhalation)	<a href="http://www.epa.gov/ttn/fera/hem_download.html">http://www.epa.gov/ttn/fera/hem_download.html</a>
Hazardous Air Pollutant Exposure Model (HAPEM)	Inhalation exposure for census block or larger area	Annual, seasonal and monthly air pollutant concentrations at census tract or block level	Human exposure concentrations	<a href="http://www.epa.gov/ttn/fera/human_hapem.html">http://www.epa.gov/ttn/fera/human_hapem.html</a>
Chemical Screening Tool For Exposures & Environmental Releases (ChemSTEER)	Occupational exposure (inhalation and dermal) and environmental releases during industrial and commercial uses	Information on the worker activities and default parameters	Release amount in kg/day and exposure dose rate in mg/day	<a href="http://www.epa.gov/oppt/exposure/pubs/chemsteer.htm">http://www.epa.gov/oppt/exposure/pubs/chemsteer.htm</a>
Exposure Analysis Modeling System (EXAMS)	Exposure to synthetic organic chemicals in a water body	Pollutant chemical properties and reaction rates	Surface water concentrations	<a href="http://www.epa.gov/ceampubl/swater/exams/exams2980406.htm">http://www.epa.gov/ceampubl/swater/exams/exams2980406.htm</a>
Exposure and Fate Assessment Screening Tool (E-FAST)	Consumer products exposure assessment	Media of release, days per year of release	Potential inhalation, dermal, and ingestion dose rates resulting from chemicals released from consumer products	<a href="http://www.epa.gov/oppt/exposure/pubs/efast.htm">http://www.epa.gov/oppt/exposure/pubs/efast.htm</a>
Multi-Chamber Concentration and Exposure Model (MCCEM)	Inhalation exposure to chemicals released from residential products or materials in rooms within a residence, school or office	Type of residence, zone volumes, interzonal air flow rates, and air exchange rates	Air concentrations and inhalation exposure for one chemical in up to four zones (rooms) of a residence	<a href="http://www.epa.gov/oppt/exposure/pubs/mccem.htm">http://www.epa.gov/oppt/exposure/pubs/mccem.htm</a>
Dietary Exposure Potential Model (DEPM)	Dietary exposure to pesticides and environmental contaminants	Food information; chemicals; population information	Chemical residues found in diet for each cohort group in mg/kg body weight per day	<a href="http://www.epa.gov/nrlcwww/depm.htm">http://www.epa.gov/nrlcwww/depm.htm</a>
Stochastic Human Exposure and Dose Simulation Model for Particulate Matter (PM) (SHEDS-PM)	PM exposure assessment that can isolate home, vehicle, building, and outdoor exposure	Population cohort(s); Ambient PM concentrations	Human exposures, intake doses	In development – model has been peer-reviewed – beta version available from Janet Burke ( <a href="mailto:burke.janet@epa.gov">burke.janet@epa.gov</a> )
Stochastic Human Exposure and Dose Simulation Model for Multimedia, Multipathway Chemicals (SHEDS-MM)	Exposure estimates for residential indoors/outdoors and national population estimates for inputs to risk assessments	Population cohort(s); input probability distributions; chemical application scenarios (optional)	Human exposures, intake doses	<a href="http://www.epa.gov/scipoly/sap/meetings/2007/081407_mtg.htm">http://www.epa.gov/scipoly/sap/meetings/2007/081407_mtg.htm</a> (model located under meeting materials)
Stochastic Human Exposure and Dose Simulation Model for the Wood Preservative Exposure Scenario (SHEDS-Wood)	Chromated Copper Arsenate (CCA) exposure assessment for outdoor playgrounds for an individual and national population estimates	Population cohort(s); input probability distributions	Human exposures, intake doses	<a href="http://www.epa.gov/scipoly/sap/meetings/2003/120303_mtg.htm">http://www.epa.gov/scipoly/sap/meetings/2003/120303_mtg.htm</a> (model located under meeting materials)
Stochastic Human Exposure and Dose Simulation Model for Air Toxics (AT) (SHEDS-AT)	Human exposure assessment from air toxics that can isolate home, vehicle, building and outdoor exposure	Hourly air concentrations	Human exposures, intake doses	In development – model has been peer-reviewed – beta version available from Janet Burke ( <a href="mailto:burke.janet@epa.gov">burke.janet@epa.gov</a> )



### Web-Based GIS Tools

Table 2 summarizes web-based GIS tools that map information from environmental databases, such as particulate matter measurements, locations of regulated facilities, demographic information, and watershed features. It was required that these tools allow the user to specify the geographic domain to be mapped. GIS tools that include detailed modeling components and were developed primarily for EPA research and development but are publicly available were also included, such as the Regional Air Impact Modeling Initiative and the Internet Geographical Exposure Modeling System. The GIS tools presented in Table 2 primarily aid with issue identification and prioritization, are web-based, and are easily accessible.

The attributes summarized in Table 2 include mapping features and the databases from which the information is drawn. The Mapping Features column briefly describes the actual information that is mapped by the tool, such as facility location or air quality monitor locations. The Databases Accessed column allows the user to see from which database the information is drawn. Most of the GIS tools provide various layers that can be turned on or off to map different types of information on the same map.

Other organizations and agencies have developed similar tools that are popular among community project teams, including Scorecard ([www.scorecard.org](http://www.scorecard.org); sponsored by the Green Media Toolshed), which includes issue ranking, and AirNow ([www.airnow.gov](http://www.airnow.gov); an inter-agency website). Scorecard presents information on various pollutants and issues related to them, including toxic releases, lead, air and water pollution, animal waste, environmental justice, and health hazards. AirNow focuses on real-time air quality across the nation, including the air quality index, ozone, particles, and ultraviolet radiation, and provides educational resources targeted for different audiences (e.g., children, students, and teachers). These tools describe their informational sources and methodologies; other tools that fail to do so should be used with caution.

### Guidance Documents

Guidance documents presented in Table 3 are stand-alone publications that provide information and suggested approaches to either identify or reduce human health risks in a community. Issues addressed by the guidance documents include air toxics, lead, radon, asbestos, and others. The Application column describes the environmental hazards addressed and the general approach, and the Audience column describes for whom the document was generally intended, such as local community groups, environmental scientists, small business owners, or government officials. About a quarter of the documents are geared toward community groups.

Generally, guidance documents in this table include a step-by-step approach to identify or prioritize environmental

hazards, such as the Community Air Screening How-To Manual (USEPA, 2004). One such document not developed by the EPA but in wide and well-accepted use, especially by public health organizations, is the Protocol for Assessing Community Excellence in Environmental Health (PACE EH) promoted by the National Association of County and City Health Officials (NACCHO) and the National Center for Environmental Health (NCEH, 2008). PACE EH guides users through an iterative process to identify and rank locally relevant environmental health indicators that reflect community values and priorities (Higman et al. 2007). Another example of a community guidance framework is the Community Tool for Health and Resilience in Vulnerable Environments (THRIVE), which combines environmental and social factors. THRIVE was developed by The Prevention Institute (THRIVE, 2004) and has been implemented in pilot studies in diverse communities (Davis et al., 2005).

### Databases by Media

Databases allow users to download available environmental information for their own analyses. EPA program offices each list their databases on their individual web pages, so we conducted a thorough review of these to provide a central list of databases (Table 4) that are publicly available and include an online query function. The table includes both multimedia and single-medium databases. The Content column describes the information in the database, and the Updates column refers to the frequency by which new information is added. Several databases are grouped within the Envirofacts Data Warehouse (which includes the GIS component, Enviromapper). Others are stand-alone databases that inform compliance assistance programs, or state or federal regulatory programs. Databases in the form of reports or tables were not included unless they were linked to umbrella databases such as the Envirofacts Warehouse.

### Exposure Models

Table 5 provides information on EPA-developed exposure models available to researchers. Exposure is defined here as contact between a chemical and the external surface of a person (e.g., skin, nostrils, mouth); singularly developed fate and transport or dose estimation models, though often used to inform exposure assessments, were not included. Most of the models presented in the table are currently available online in their final version with their respective user manuals and documentations. The specific Offices that were involved in developing these models include the EPA Offices of Research and Development, Air and Radiation, Air Quality Planning and Standards, Pollution Prevention and Toxics, and Pesticide Programs. Table columns include Model, Objective, Inputs, Outputs, and Availability.

As a group, the models consider multiple routes of exposure including inhalation, dermal, and dietary and

non-dietary (hand-to-mouth and object-to-mouth) ingestion. However, most of the models focus on inhalation exposures. The majority of the models require that the user be relatively familiar with the basic exposure assessment terminology; however, three screening-level models include HEM-3, HEM-Screen, and E-Fast, and are more tailored for the novice user. Some of the more widely used non-EPA exposure models are CalTOX, IRAP, and Lifeline. These models are also available for public use and can be located using a general online search engine.

We were especially interested in finding models that incorporate human activity patterns and allow the user to select population groups of interest (i.e., cohort selection). Activity patterns can greatly influence average lifetime exposure and risk (McCurdy et al., 2000), and all of the models, except for E-Fast and the HEM models, explicitly incorporate human activity data. Cohort selection allows specific groups of individuals to be evaluated, such as susceptible populations such as children or the elderly, but several of the models do not include this feature.

#### *Measurement Methods*

Occasionally, community-based initiatives may find the need to record measurements of pollutants that may be affecting human health, to assess the levels of exposure within the community. Measurement methods can range from screening level, such as the presence or absence of a pollutant, to precise quantitative methods that measure actual concentrations. Various monitoring kits are publicly available, but monitoring studies can be inherently difficult to conduct and can yield results that are difficult to interpret and communicate to community members (Payne-Sturges et al., 2004; Quandt et al., 2004), so a certain amount of caution and preparedness should be involved in these studies. A separate publication has been prepared to describe the variety of measurement kits available and some of the inherent complexities of monitoring studies (Medina-Vera et al., 2009).

#### **Discussion**

This research provides an overview and assesses tools based on the perspectives of CBCRA participants and researchers. This perspective was developed through a literature review, an informational survey, quarterly CARE reports, and numerous meetings and discussions with CARE and CBCRA researchers and participants. Over 70 tools were examined and 25 CARE project officers were interviewed, and numerous other researchers were involved in communications. A literature search was performed to determine the role of the tools in published research studies. The tools, projects, and participants comprised a comprehensive sample of the current state of EPA efforts for CBCRAs.

This section focuses on the utility of current tools and recommendations for future tool development. It covers the following: (1) current use of tools; (2) how extensively tools cover CBCRA-associated risks and research needs; (3) benefits and limitations of tools; and (4) gaps in the science and recommendations for future tool development. This discussion is intended to help CBCRA participants identify useful tools, and guide research for new tool development.

#### *Current Use of Tools*

On the basis of our communications, we found that the majority of available tools were not being used in CBCRA projects. One of the tools applied most successfully was PACE EH, a non-EPA tool (e.g., Hubbard, 2006; Higman et al., 2007), which guides users through hazard identification and includes a prioritization method, which is often lacking in other tools. Some databases, including the Toxic Release Inventory (TRI) and the National Emissions Inventory (NEI), had been used to gather information on industrial emissions, but primarily by scientific researchers and not CBCRA groups (e.g., Fung and O'Rourke, 2000). Community concerns may be non-chemical in nature, affecting quality of life and potentially increasing health-risk vulnerability, but to date tools do not address these types of issues.

In many cases, CARE partnerships relied on round table discussions to identify potential environmental hazards. This proved to be an effective method for covering the breadth of issues faced by a specific community; however, the method often draws heavily on risk perception rather than science and quantifiable evidence. Once the myriad issues were identified, groups were challenged to prioritize them because of the stumbling block of gathering relevant information such as about health effects, predominance in the community, or steps by which to take action. The general lack of knowledge about tool availability promotes this difficulty in making informed decisions.

Other reported challenges included interpreting and presenting tool output. For example, NATA, (1999; Table 4) provides census tract-level information in tabular format and county-level information as maps for air toxic concentrations, exposures, and health risks. However, although a handful of groups showed knowledge of the existence of NATA, they professed that using the tool, interpreting the results, and presenting information were limiting factors to using the tool.

#### *Intersection of Current Tools with CBCRA Research Needs*

Several tools intersect with community-related issues presented in Table 1, but they are spread across Agency websites and operate independently of one another. For example, industrial emissions, brownfields, air toxics, household hazardous waste, and asbestos have all been identified as important community-related environmental hazards (Table 1). Separate GIS tools are available for industrial

emissions, brownfields, and air toxics (Table 2), and guidance documents for air toxics, household hazardous waste, and asbestos (Table 3). However, compiling information for a CBCRA may be challenging, as output formats across tools are not necessarily compatible to produce a direct comparison or overlay.

As a group, the tools cover a range of media and pollutants, but individually, each tool is typically geared toward a particular medium or pollutant. GIS tools (Table 2) generally address air and water issues or map-regulated facilities, such as those listed in the NEI or TRI. The EnviroMapper Storefront (Table 2) includes 10 different mapping tools that each draws from its own national database. NATA (Table 4) addresses 177 air toxic types, concentrations, exposures, and hazards; maps are produced at the county level, but census tract-level output, applicable to CBCRAs, is available only in tabular format. Guidance documents (Table 3) also address a variety of environmental hazards, including air toxics, superfund sites, and watershed management; however, only a quarter of them were prepared for community-based workgroups. Overall, the databases (Table 4) address multimedia issues, air pollutants, radiation, hazardous waste, compliance data, and other information such as information about EPA grants; however, mining and analyzing information may be challenging without technical training.

#### *Benefits and Limitations of Available Tools*

A critical limitation of the tools presented here is that they do not address risk ranking. Groups involved in CBCRAs typically have limited resources, either financially or involving human resources or time. Risk ranking for a CBCRA often evolves into issue prioritization, as the latter is based on what can be done with the available resources, which means that the highest health risk may not be the topmost priority. The tools presented here generally do not address the step of issue prioritization or risk ranking, although the methods proposed for this step have been published in the literature (Florig et al., 2001).

Each tool category showed specific benefits and limitations. Although the GIS tools aid with issue identification, the user would have to visit several tools to address the various separate issues, and in most cases the output cannot be exported into formats that can be merged. A benefit of guidance documents is that some of them provide an overview of the general concept of cumulative risk assessments (e.g., Framework for Cumulative Risk Assessments and Risk Assessment Guidelines; USEPA 2003); a limitation is that they generally address a singular issue, which would be useful for addressing a specific hazard, though not multiple ones. Analyzing database information is often outside the scope of the technical expertise of community-based projects, and is generally more useful if academic or agency partners are available for collaboration (e.g., Keeler et al., 2002). A

limitation of the databases is that they do not address some community-identified issues, such as agricultural pesticides. Exposure models often require a high level of technical expertise as well as inputs of environmental measurement data, and are rarely used in CBCRAs; their results can also be difficult to interpret without a working knowledge of exposure assessments. Their information, however, could be useful for presenting exposure and risk characterizations visually (e.g., GIS maps) to a community.

#### *Development of New and Improved Tools*

On the basis of our findings, new and improved tools should be based on feedback from community groups, project officers, and groups or agencies familiar with CBCRAs. This promotes the efficient use of resources for tool development, and a regular feedback loop between developers and users. Tools should allow communities to define the problem and required information, supply local knowledge, and interpret results in the local context (Fox et al., 2002; Corburn, 2002b). They should be transparent, accessible to non-scientists, reflective of local input, targeted to solutions, and provide output in a timely manner.

Future tools should address cumulative exposures and risks, as opposed to a single medium, pollutant, or pathway. Further research should be drawn from published case studies on community cumulative risk assessments (Fox et al., 2002; Minkler et al., 2008). Non-chemical stressors should also be incorporated in risk assessments as research on these stressors evolves (Zartarian and Schultz, 2009). These include socioeconomic factors, behavioral factors, structural factors, and the built environment (Davis et al., 2005; Hood, 2005; Brouwer et al., 2007; Farhang et al., 2008).

The CCRP is in the initial phases of developing a web-based tool to address many of these needs. The Community-Focused Exposure and Risk Screening Tool (C-FERST) draws on the research presented here to address multiple stressors at the community level, with constant collaboration between the developers and the users (Zartarian and Schultz, 2009). It will focus on multiple stressors and provide community-level exposure and risk characterizations to aid with issue identification and prioritization. It will also present its findings in a summary community report with GIS maps, where possible, to facilitate interpretation and communication.

#### **Conclusions**

The tables presented here can be used by CBCRA participants to promote issue identification, prioritization, and mitigation, and by researchers to inform future tool development. Findings indicate that tools generally cover a wide variety of pollutants and sources, but separately and individually of one another. New tools would present a more comprehensive assessment of the environmental concerns of

communities, and include cumulative effects and non-chemical stressors.

The tables focus on EPA tools to present a sample of current CBCRA-related tools that have undergone similar review and quality assurance procedures. Non-EPA tools that have also been used in the projects we surveyed include PACE-EH, THRIVE, Scorecard, and AirNow. PACE EH is one of the most successful tools in addressing the issue prioritization step. In addition to a list of CBCRA-related environmental hazards (Table 1), the attributes of over 70 tools are summarized in the tables, which include web-based GIS tools (Table 2), guidance documents (Table 3), databases (Table 4), and exposure models (Table 5).

The compilation of information from different tools for a CBCRA can be very challenging, especially as output formats (e.g., for the GIS tools) are not necessarily consistent across tools. Our survey indicated that groups were generally unaware of the full suite and capabilities of the tools currently available. One reason for this is that tools are posted on separate EPA web pages and not centrally located. The tables have been posted online at [www.epa.gov/care/publications.htm](http://www.epa.gov/care/publications.htm). Public outreach programs could promote awareness, such as informing local health departments, train-the-trainer workshops, or incorporation into university and school environmental education programs.

New tool development should incorporate three key components: (1) collaborations with community groups and CBCRA researchers to maintain a regular feedback loop between developers and users; (2) address multiple pollutants, sources, and non-chemical stressors and potential combined effects; and (3) provide guidance for health-risk ranking and issue prioritization, the latter being related to resource availability (finances, human resources, time, and so on). C-FERST is being developed by the CCRP to address many of these requirements. It builds on the information provided here, and will address a variety of issues at the local scale and present information to aid with issue prioritization, exposure assessments, and potential health risks. The tools presented here are valuable resources; although they experience certain limitations, they draw from national databases and years of expertise and could be used effectively in CBCRA programs.

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