

# Unfounded Fears About Pollution Trading and Hotspots

by David E. Adelman

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## Summary

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EPA emissions inventory and cancer risk data for criteria pollutants and air toxics show clearly that vehicles and small stationary sources emit a majority of the air pollution nationally and account for most of the cancer risks from air toxics. Industrial sources, by contrast, rarely account for more than 10% of cumulative cancer risks from all outdoor sources of air toxics. The observed pattern of emissions is replicated at spatial scales ranging from census tracts to the nation as a whole. The secondary status of industrial facilities as sources of air pollution largely neutralizes the potential for pollution trading programs to cause hotspots. In the vast majority of jurisdictions, industrial emissions are simply too low, and in the few jurisdictions in which disparities cannot be ruled out, targeted policies exist to prevent them without compromising market efficiency. These findings are generalizable to all market-based regulations.

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The potential for pollution trading programs to cause localized hotspots of air pollution has long been a flashpoint for opposition to this form of market-based environmental regulation.<sup>1</sup> The Regional Clean Air Incentives Market, a controversial pollution trading system in southern California, was almost upended due to concerns that environmental justice advocates raised about toxic hotspots around major industrial facilities.<sup>2</sup> Similarly, the George W. Bush Administration's plan to regulate mercury emissions from electric utilities using a trading regime was opposed on the grounds that it would allow mercury emissions to concentrate around power plants.<sup>3</sup> Even the venerable sulfur dioxide (SO<sub>2</sub>) trading system for U.S. power plants has not been immune to fears that it could cause pollution hotspots,<sup>4</sup> and similar concerns are now being raised about cap-and-trade programs for greenhouse gases (GHGs).<sup>5</sup>

The potential for hotspots stems from the freedom pollution trading programs give firms to meet emissions standards. Specifically, a firm may meet their regulatory quota either through reducing their emissions or purchasing pollution credits.<sup>6</sup> Inequities could arise if large industrial facilities located in a minority or low-income community disproportionately chose to purchase permits over reducing emissions. Nothing in a pollution trading regime forecloses this result, but whether it occurs will be contingent on several factors, including the relative cost of reducing emissions at industrial facilities, the geographic distribution of industrial facilities with significant emissions, and

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1. See, e.g., Jonathan Remy Nash & Richard L. Revesz, *Markets and Geography: Designing Marketable Permit Schemes to Control Local and Regional Pollutants*, 28 *ECOLOGY L.Q.* 569, 580 (2001) (noting that academics have "focused almost exclusively on the possibility that emissions trading will [cause hotspots of air pollutants]"); Lily N. Chinn, *Can the Market Be Fair and Efficient? An Environmental Justice Critique of Emissions Trading*, 26 *ECOLOGY L.Q.* 80, 10809 (1999); Stephen M. Johnson, *Economics v. Equity: Do Market-Based Environmental Reforms Exacerbate Environmental Injustice?*, 56 *WASH. & LEE L. REV.* 111, 111-12 (1999).
  2. See Richard Toshiyuki Drury et al., *Pollution Trading and Environmental Injustice: Los Angeles' Failed Experiment in Air Quality Policy*, 9 *DUKE ENVTL. L. & POL'Y F.* 231, 268-69 (1999) (describing failures of the RECLAIM program and the deficiencies of market-based regulations generally); Lesley K. McAllister, *Beyond Playing "Banker": The Role of the Regulatory Agency in Emissions Trading*, 59 *ADMIN. L. REV.* 269, 287-312 (2007).
  3. See Catherine A. O'Neill, *Mercury, Risk, and Justice*, 34 *ELR* 11070, 11070-71 (Dec. 2004) (describing the controversy surrounding the trading regime for mercury emissions from power plants).
  4. Jason Coburn, *Emissions Trading and Environmental Justice: Distributive Fairness and the USA's Acid Rain Programme*, 28 *ENVTL. CONSERVATION* 323, 323-24 (2001); Evan J. Ringquist, *Trading Equity for Efficiency in Environmental Protection?: Environmental Justice Effects From the SO<sub>2</sub> Allowance Trading Program*, 92 *SOC. SCI. Q.* 297, 300-01 (2011).
  5. Alice Kaswan, *Reconciling Justice and Efficiency: Integrating Environmental Justice Into Domestic Cap-and-Trade Programs for Controlling Greenhouse Gases*, in *THE ETHICS OF GLOBAL CLIMATE CHANGE* 232, 240-42 (Denis G. Arnold ed., 2011); Chinn, *supra* note 1, at 80-81; Johnson, *supra* note 1, at 111-12.
  6. Nash & Revesz, *supra* note 1, at 575-77.

the relative contribution of industrial sources to emissions of air pollutants from all sources collectively.<sup>7</sup>

The federal SO<sub>2</sub> trading program for coal-fired power plants illustrates the contingency of these concerns. At the outset, one might expect this program to be highly vulnerable to hotspots given that it covers by far the largest sources of SO<sub>2</sub> emissions.<sup>8</sup> Yet, other characteristics of power plants—their tall stack heights and the temperature of their emissions—cause the emissions to disperse over large areas.<sup>9</sup> In addition, the economics of emissions controls at the largest plants has also favored reducing emissions over purchasing credits, which has further mitigated the potential for hotspots.<sup>10</sup> Thus, while the impacts are not geographically uniform, they have not led to the localized hotspots many critics had feared.<sup>11</sup>

The risks associated with pollution trading and hotspots nevertheless clearly warrant careful consideration. Unfortunately, the potential risks are usually debated in the abstract with little or no consideration of actual emissions data. Critics are often unaware or fail to consider the implications of the small relative contributions of industrial facilities collectively to aggregate emissions of most air pollutants. This Article aims to correct this oversight. Perhaps the most striking result is that industrial emissions of air toxics rarely account for more than 10% of the totals emitted at the census-tract or county level. This greatly reduces the potential impacts of a firm choosing to purchase credits rather than reducing emissions—on average, diluting the potential impacts tenfold. More concretely, an avoided 30% reduction in industrial emissions under a pollution trading scheme would have less than a 3% impact on surrounding pollutant levels.

This Article will examine empirically the likelihood that pollution trading programs could generate hotspots. I will focus particular attention on the geographic distribution of industrial facilities and their relative contributions to aggregate air emissions. The U.S. Environmental Protection Agency (EPA) maintains several databases on air emissions and cumulative cancer risks from air toxics

that provide an unprecedented level of information and that have not received the attention they deserve.<sup>12</sup> The EPA data reveal that, apart from a few readily identifiable areas, the potential for pollution trading to cause hotspots is minimal. Moreover, for the few areas in which disparities cannot be ruled out, targeted policies exist to prevent them without compromising market efficiency.

## I. The Dominance of Small Sources of Air Pollution

I expect that many people, if asked, would identify industrial facilities as among the most important sources, if not the single largest source, of air pollution in the country. Debates over clean air policy reinforce this view, both with respect to their focus on regulating major industrial sources and their neglect of the implications of the close association between poor air quality and urbanization. The legal literature on the Clean Air Act (CAA)<sup>13</sup> tends to focus either on high-level theories, such as debates over the use of cost-benefit analysis in setting national ambient air quality standards (NAAQS), the merits of uniform technology-based standards, and the virtues of market-based regulations,<sup>14</sup> or discrete categories of sources.<sup>15</sup> These divergent perspectives, either abstract or narrowly focused, tend to omit much of the context in which clean air policies are implemented.

The discussion in the subsequent sections will examine the spatial patterns of air pollution in the United States. In addition to the data on criteria pollutants, the analysis will evaluate emissions data and cancer risk estimates for air toxics. There are two primary reasons for analyzing them together: (1) they are often emitted by the same sources and thus are impacted by regulations under their respective programs; and (2) the cancer risk data available for air toxics are valuable insofar as they provide a complementary and more fine-grained picture of air pollution nationally. The analysis will focus on the key criteria pollutants (volatile organic compounds (VOCs), nitrous oxides (NO<sub>x</sub>), SO<sub>2</sub>, and fine particulate matter (PM<sub>2.5</sub>) and a small subset

7. See TODD SCHATZKI & ROBERT N. STAVINS, ADDRESSING ENVIRONMENTAL JUSTICE CONCERNS IN THE DESIGN OF CALIFORNIA'S CLIMATE POLICY 6-14 (2009), available at [http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Environmental\\_Justice.pdf](http://www.analysisgroup.com/uploadedFiles/Publishing/Articles/Environmental_Justice.pdf).

8. See *infra* Figure 4.

9. Nash & Revesz, *supra* note 1, at 575-76 (describing the mitigation of localized impacts by the height of the smoke stacks at power plants and the temperature of emissions); Lawrence I. Kleinman et al., *A Comparative Study of Ozone Production in Five U.S. Metropolitan Areas*, 100 J. GEOPHYSICAL RES. 1-2 (2005) (describing the different processes and time lines that cause ground-level ozone to spread out over large areas).

10. Dallas Burtraw & Sarah Jo Szambelan, U.S. EMISSIONS TRADING MARKETS FOR SO<sub>2</sub> AND NO<sub>x</sub> 8 (2009) (describing studies showing that under the U.S. SO<sub>2</sub> trading market, “[t]he greatest reductions in emissions by far (in tonnage and percentage) were in the Midwest, the area with the greatest power plant emissions historically”), available at <http://www.rff.org/RFF/Documents/RFF-DP-09-40.pdf>.

11. Gabriel Chan et al., *The SO<sub>2</sub> Allowance Trading System and the Clean Air Act Amendments of 1990: Reflections on Twenty Years of Policy Innovation* 22 (Feb. 2012), NBER Working Paper No. 17845, available at <http://www.nber.org/papers/w17845> (noting that benefits of the SO<sub>2</sub> trading program have not been geographically homogeneous, although the geographic scale of the variation is very large).

12. EPA maintains two databases on toxic emissions, the National Emissions Inventory and Toxics Release Inventory, and one on cancer risks, the National-Scale Air Toxics Assessment. See *infra* Part I.A., for details.

13. 42 U.S.C. §§7401-7671q, ELR STAT. CAA §§101-618.

14. See, e.g., Gary Coglianese & Gary Marchant, *Shifting Sands: The Limits of Science in Setting Risk Standards*, 152 U. PA. L. REV. 1255, 1340-46 (2004) (arguing that costs should be considered when setting NAAQS); Richard J. Pierce, *The Appropriate Role of Costs in Environmental Regulation*, 54 ADMIN. L. REV. 1237 (2002) (arguing that ways exist for EPA to work around the CAA's rule against considering costs when setting NAAQS); Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267 (1985) (arguing in favor of uniform standards under statutes such as NAAQS under CAA on the grounds of efficiency in practice); William F. Pederson, *Why the Clean Air Act Works Badly*, 129 U. PA. L. REV. 1059, 1060-61 (1981) (arguing that the CAA's strict deadlines and elaborate procedures impede the refinement of policies as new scientific knowledge becomes available).

15. See, e.g., Bruce A. Ackerman & William T. Hassler, *CLEAN COAL DIRTY AIR* 10-12 (1981) (discussion of the inefficiency of narrow technology-based standards under the CAA's New Source Performance Standards).

of air toxics, referred to here as the NATA Toxics,<sup>16</sup> that are responsible for most of the cancer risks nationally.<sup>17</sup> Before proceeding with the discussion, the next section will describe the EPA data and their limitations.

### A. EPA Air Pollution Inventories and Cancer Risk Estimates

EPA has defined four categories of sources (point, nonpoint, onroad mobile, offroad mobile), which I will use throughout the Article with one important qualification.<sup>18</sup> The terms “industrial source” and “point source” will be used interchangeably even though the point-source category includes smaller manufacturers and can encompass conventional nonpoint sources such as gas stations and dry cleaners.<sup>19</sup> Treating data on point sources as though they are limited to industrial sources will cause the estimates of emissions and risks from industrial sources to be conservative by virtue of being overinclusive. A benefit of this approach is that it operates as a rough offset for potential errors in the EPA data.

The analysis draws on three EPA databases (see Table 1), one that covers criteria pollutants and air toxics, and two that are specific to air toxics. EPA collects two types of data on air toxics—pollutant emissions levels and cumulative cancer risk estimates. The two types of data provide complementary views of air pollution across the country, as each metric has its limitations. Broad trends in emissions of air toxics, for example, reveal the relative importance of different source categories, whereas risk estimates provide a direct measure of harm but are subject to large uncertainties. The risk data for criteria pollutants are more limited; EPA releases only categorical data on whether a jurisdic-

**Table 1: EPA Emissions and Cancer Risk Databases for Air Toxics**

Database Name	Metric	Sources Covered	Years Compiled
Toxic Release Inventory (Air Toxics)	Emissions (Pounds)	Major point sources	Annually (1988-2010)
National Emissions Inventory (Air Toxics & Criteria Pollutants)	Emissions (Tons)	All source categories	Tri-Annually (2005, 2002, 1999, 1996)
National-Scale Air Toxics Assessment (Air Toxics)	Cancer Risk (excess mortality per million)	All source categories	Tri-Annually (2005, 2002, 1999, 1996)

tion is or is not in attainment for a NAAQS—direct risk estimates are not available.

The emissions inventory data will be drawn from the Toxic Release Inventory (TRI) and the tri-annual National Emissions Inventory (NEI). The TRI data are based on annually reported emissions of air toxics from major industrial sources,<sup>20</sup> whereas the NEI data encompass emissions from all outdoor sources of air toxics and criteria pollutants (i.e., large and small stationary sources, onroad and nonroad mobile sources).<sup>21</sup> With the exception of VOCs, the data on criteria pollutants are quite reliable because they are relatively easy to measure and have been subject to extensive monitoring.<sup>22</sup> By contrast, only a subset of the data in the TRI and NEI are derived from direct measurements of VOC or air toxics emissions; most of the data are based on estimates derived from algorithms because direct measurement is difficult.<sup>23</sup> Nevertheless, although significant errors and uncertainties persist in the TRI and NEI data, they are approaching a level of reliability that experts view as reasonable (within a factor of two of direct measurements), and this is particularly true of the pollutants that pose the greatest risks.<sup>24</sup>

The second type of data cover cancer risk estimates that EPA generates tri-annually under NATA.<sup>25</sup> The cancer risk estimates use the NEI emissions data as an input for the EPA exposure models (i.e., fate and transport of air toxics).<sup>26</sup> The NATA results are thus dependent on the accuracy of the NEI data, the EPA exposure models, and toxicity estimates for each compound. The complexity of the analyses that underlie the NATA cancer risk estimates introduces numerous opportunities for uncertainty and

16. NATA stands for National-Scale Air Toxics Assessment.

17. The NATA Toxics, which EPA has identified as national or regional risk drivers in the 2005 NATA, include the following chemicals: 1,3 Butadiene; 1,4 Dichlorobenzene; Acetaldehyde; Acrylonitrile; Benzene; Chromium Compounds; Formaldehyde; Naphthalene; Polycyclic Aromatic Hydrocarbons; and Tetrachloroethylene. U.S. EPA, SUMMARY OF RESULTS FOR 2005 NATIONAL-SCALE ASSESSMENT 3-4 (Mar. 2011) (identifying these chemicals as national and regional “cancer risk drivers”).

18. Point sources include large industrial facilities, but also may include smaller commercial facilities, such as dry cleaners and gas stations. Nonpoint sources (previously “area sources”) include all stationary sources not treated as “point sources” because their locations cannot be accurately measured at the facility level (for example, small manufacturers, fireplaces/wood stoves, and prescribed burns). Mobile sources include onroad vehicles (for example, cars, trucks, and buses) and nonroad sources (for example, trains, ships, construction equipment, and farm machinery). Background emissions include natural sources, persistent air toxics (for example, those originating from a previous year’s emissions), and long-range emissions (for example, those greater than 50 kilometers). ICF INT’L, AN OVERVIEW OF METHODS FOR EPA’S NATIONAL-SCALE AIR TOXICS ASSESSMENT 19 (2011) [hereinafter NATA OVERVIEW], available at [http://www.epa.gov/ttn/atw/nata2005/05pdf/nata\\_tmd.pdf](http://www.epa.gov/ttn/atw/nata2005/05pdf/nata_tmd.pdf).

19. *Id.*

20. U.S. EPA, Basics of TRI Reporting, available at <http://www.epa.gov/tri/tri-program/businesscycle/index.html> (the TRI covers certain listed industries and any company with greater than 10 employees that manufactures or processes greater than 25,000 pounds (lbs.) of TRI-listed chemicals annually or otherwise uses more than 10,000 lbs. of a listed chemical in a given year).

21. U.S. EPA, 2005 National Emissions Inventory Data & Documentation (Dec. 2011) (descriptions of data and detailed documentation on the 2005 NEI), available at <http://www.epa.gov/ttn/chief/net/2005inventory.html>.

22. *Id.*

23. U.S. EPA Office of Inspector General, EPA CAN IMPROVE EMISSIONS FACTORS DEVELOPMENT AND MANAGEMENT 4 (Mar. 2006), available at <http://www.epa.gov/oig/reports/2006/20060322-2006-P-00017.pdf> (noting that emissions factors and simple algorithms are used for about 80% of emissions determinations).

24. U.S. EPA, RESULTS OF THE 2005 NATA MODEL-TO-MONITOR COMPARISON 1-1, 2-4 (Dec. 2010), available at [http://www.epa.gov/ttn/atw/nata2005/05pdf/nata2005\\_model2monitor.pdf](http://www.epa.gov/ttn/atw/nata2005/05pdf/nata2005_model2monitor.pdf).

25. The cancer risks are expressed as “typical lifetime excess cancer risk” of, for example, 10 per million. NATA Overview, *supra* note 18, at 70.

26. *Id.* at 71-77 (describing the sources of uncertainty in deriving cumulative risk estimates for air toxics).

bias in the results.<sup>27</sup> Thus, while the NATA data provide a direct measure of risk, they must be interpreted cautiously.<sup>28</sup>

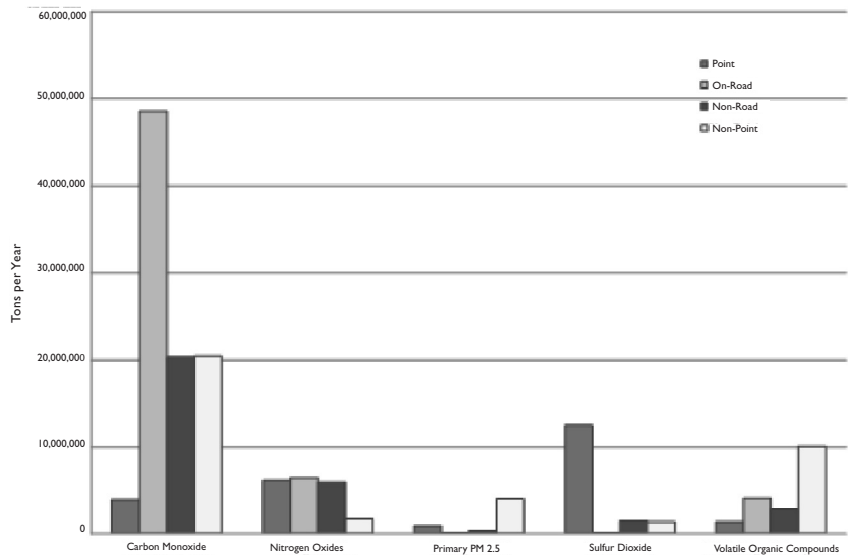
EPA maintains that the estimates of relative contributions across source categories are among the most robust,<sup>29</sup> but the uncertainties will be substantial for even the best (typically more aggregated) data. The various sources of error are factored into a rough bounding analysis described in a prior article,<sup>30</sup> which shows that apart from a small number of jurisdictions the potential errors would not alter the conclusions of the analysis that follows.

## B. Geographic Scales of Air Pollution in the United States

There are two striking patterns in the source-category data. First, motor vehicles and nonpoint source consistently account for a disproportionate share of the air pollutants emitted. A simple accounting of the criteria pollutants and NATA Toxics emitted by each source category clearly shows that such diffuse sources are responsible for most of the emissions. Figure 1 displays the 2005 data for criteria pollutants.<sup>31</sup> Industrial sources were the primary source for SO<sub>2</sub>, but one must keep in mind that a single type of facility, coal-fired power plants, emits about 80% of SO<sub>2</sub> nationally. For all of the other criteria pollutants, motor vehicles and nonpoint sources generated the lion's share of the emissions.

The national source-category emissions for air toxics roughly mirror those of the criteria pollutants. Industrial sources accounted for about 13% of the air toxics emitted nationally in 2005, whereas motor vehicles and nonpoint sources (e.g., gas stations, dry cleaners, and landfills) accounted for 48% and 39%, respectively.<sup>32</sup> These averages are fairly representative of variation in the underlying data—industrial facilities rarely accounted for more than one-quarter of aggregate toxic emissions from outdoor

**Figure 1: 2005 National Emissions of Criteria Pollutant by Source Category**



sources at either the county or census-tract level. Moreover, the distribution of emissions across source categories has been relatively stable since at least the mid-1990s.<sup>33</sup>

The observations for the NATA Toxics collectively are reinforced by the data on individual NATA Toxics (Figure 2). Setting aside chromium (not shown below), all of the leading air toxics are weakly associated with industrial emissions.<sup>34</sup> The disaggregated data also highlight the degree to which emissions are skewed toward a smaller number of pollutants—benzene and formaldehyde are emitted in much larger quantities than the other NATA Toxics. Predictably, both are significant byproducts of combustion, although formaldehyde tends to have a broader range of nonpoint sources, whereas benzene is a component of gasoline and highly correlated with mobile sources.

## I. County-Level Data and Urban Hotspots

Motor vehicles and nonpoint sources account for an even higher share of the criteria pollutants and air toxics emitted in large metropolitan areas. Typically, their share is above 80% for criteria pollutants, whereas industrial sources generally account for 6-15% of NO<sub>x</sub> emissions, 15-30% of PM<sub>2.5</sub> emissions, and less than 10% of VOC emissions.<sup>35</sup> Further, the departures from these levels, which occur most often with NO<sub>x</sub> and PM<sub>2.5</sub>, are almost invariably associated with large coal-fired power plants. The consistency of the data and simple logic of the outliers lend additional credence to the overall picture presented by the EPA data.

27. For intra- and interjurisdictional comparisons, it is critical to keep in mind that the quality and detail of information differ significantly depending on the geographic scale of the data, uncertainties are greater at smaller scales, and by jurisdiction. See David E. Adelman, *The Collective Origins of Toxic Air Pollution: Implications for Greenhouse Gas Trading and Toxic Hotspots*, 88 IND. L.J. 273, 294-97 (2013).

28. In particular, because of the spatial averaging over a census tract (or county) "individual exposures or risks might differ by as much as a factor of 10 in either direction [i.e., above or below a calculated mean]." NATA OVERVIEW, *supra* note 18, at 69. Similarly, EPA claims that NATA is a useful indicator of potential health risks from air toxics at "a given point in time," but different NATAs cannot be compared because the pollutants differ between them. Government Accountability Office, *Clean Air Act: EPA Should Improve the Management of Its Air Toxics Program* 28-29 (June 2006).

29. *Id.* at 5.

30. Adelman, *supra* note 27, at 333-34.

31. Carbon monoxide and lead are omitted in Figure 5. Nonpoint, onroad, and nonroad sources accounted for about 95% carbon monoxide emissions in 2005.

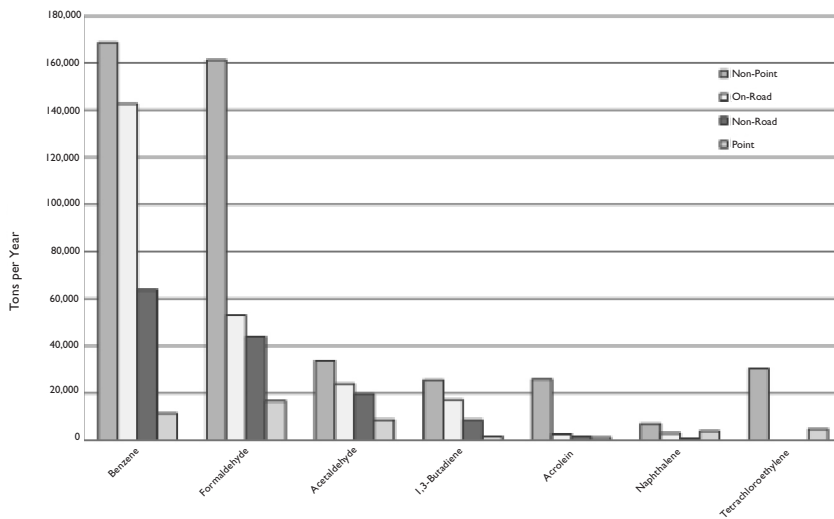
32. Adelman, *supra* note 27, at 293.

33. *Id.*

34. Other than mercury, chromium is the most important air toxic emitted by industrial sources (particularly steel mills and foundries), which account for about 80% of chromium emissions nationally. *Id.* at 230-21.

35. As the industrial capital of the United States, Houston provides a conservative benchmark, and yet its industrial sources emitted just 30% of the NO<sub>x</sub>, 27% of the PM<sub>2.5</sub>, and 22% of the VOCs.

**Figure 2: 2005 National Emissions of NATA Toxics by Source Category**



The patterns of urban emissions of NATA Toxics are a little more variable. Figure 3 displays the source-category emissions for the counties with the highest emissions levels; it shows a steep drop in emissions across the top four or five counties, all of which cover major metropolitan areas (e.g., Chicago, Houston, Los Angeles). Emissions from industrial sources are reflected in the top segment of each bar and, for all but Houston, account for less than 10% of the aggregate emissions. Houston is notable for having—by a huge margin—the largest concentration of industrial facilities in the country.<sup>36</sup> Thus, the fact that industrial sources in Houston accounted for only one-quarter of the NATA Toxics emitted is actually further evidence that small

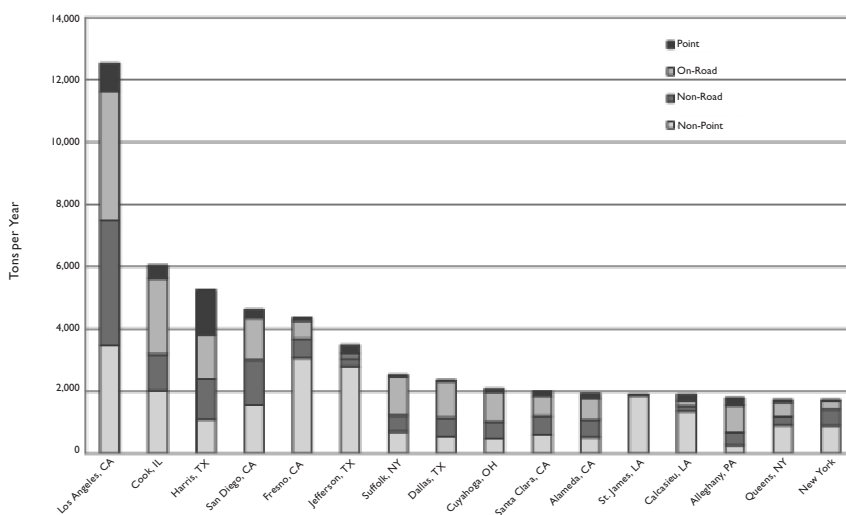
sources have the greatest impact on air quality in urban areas.

The county data for criteria pollutants and air toxics must be interpreted carefully, however, as counties vary greatly in size. For example, New York County encompasses a mere 23 square miles, but has a population of 1.6 million, which equates to 71,000 people per square mile. Toward the other end of the spectrum, Harris County, in which Houston is located, encompasses 1,729 square miles and has a population of 4.1 million, which equates to 2,367 people per square mile. Yet, the geographic variation notwithstanding, metropolitan areas with the highest emissions are generally the places most likely to be in nonattainment for one or more NAAQS and to have the highest cancer risks.

## 2. Cancer Risks by Census Tract

The cancer risk data available for air toxics reinforce the findings from the emissions data. They are of particular value because they provide a direct measure of the average risks posed by each source category. In relative and absolute terms, the cancer risks from industrial sources in most census tracts are quite modest, averaging about three per million nationally in 2005 (the national average was 50 per million).<sup>37</sup> In relative terms, industrial sources accounted for more than 50% of the cumulative risks from all outdoor sources of air toxics in just 65 tracts and for more than 30% in 297 tracts (see Table 2 on the next page). Spatially, about 98% of the U.S. population in 2005 lived in census tracts where industrial sources were responsible for cancer risks below 10 per million, whereas about 153,000 people (0.5% of the U.S. population) lived in census tracts where industrial sources (typically a steel mill or foundry) generated cancer risks in excess of 100 per million.

**Figure 3: County-Level Emissions of NATA Toxics in 2005**



The risks from industrial sources can also be evaluated using a combination of absolute and relative metrics. For example, one could single out census tracts in which industrial emissions of air toxics generated cancer risks of at least 20 per million *and* accounted for more than 30% of the cumulative cancer risks. Using this conservative combination of metrics, just 240 census tracts out of 65,000 nationally would have qualified in 2005. To put this in a broader perspective, cancer risks from industrial sources exceeded five per mil-

36. Adelman, *supra* note 27, at 299-300.

37. U.S. EPA, SUMMARY OF RESULTS FOR THE 2005 NATIONAL-SCALE ASSESSMENT 4 (2011), available at [http://www.epa.gov/ttn/atw/nata2005/05pdf/sum\\_results.pdf](http://www.epa.gov/ttn/atw/nata2005/05pdf/sum_results.pdf) [hereinafter U.S. EPA, SUMMARY OF RESULTS].

**Table 2: Census Tracts in Which Cancer Risks From Industrial Emissions of Air Toxics Exceeded 10 per Million**

	Percent Point Sources	Percent Mobile Sources	Percent Secondary Sources
Min	5.19	0.49	6.24
First Quartile	17.18	9.43	24.13
Second Quartile	22.36	15.40	29.41
Third Quartile	30.06	25.36	33.96
Max	87.48	66.09	54.39

lion (10% of the national average) in just 6% of all census tracts (3,792 in total).<sup>38</sup> These results highlight the degree to which small sources dominate emissions of air toxics nationally.

Alternatively, one can evaluate the relative contribution to cancer risks from industrial sources in the census tracts with the highest cumulative risks from all outdoor sources of air toxics. Cumulative cancer risks exceeded 100 per million in 3,100 census tracts nationally (see Table 3). A disproportionate share of these census tracts were located in the Los Angeles or New York metropolitan areas,<sup>39</sup> which highlights the strong correlation between heightened risks from air toxics and intense urbanization.

**Table 3: Census Tracts in Which Cumulative Cancer Risks From All Outdoor Sources of Air Toxics Exceed 100 per Million**

	Percent Point Sources	Percent Mobile Sources	Percent Secondary Sources
Min	0.09	6.24	0.81
First Quartile	1.42	22.44	31.43
Second Quartile	2.01	27.98	36.48
Third Quartile	3.14	33.69	42.14
Max	87.48	56.96	74.70

Among the census tracts with the highest cumulative cancer risks, industrial sources were typically a minor factor in relative terms. For about three-quarters of the tracts, industrial emissions accounted for less than 3% of the cumulative cancer risk (see Table 3). These numbers are dramatically lower than most people might predict, and they challenge conventional beliefs about industrial emissions and their association with cancer risks in the vast majority of U.S. jurisdictions. They also highlight the degree to which the highest cancer risks from air toxics are largely attributable to mobile and nonpoint sources.

These results must be interpreted cautiously for three primary reasons. First, the spread in cancer risks over the

top 1,000 census tracts was small in relative terms—a little more than a factor of two. Yet, an ordinal ranking of census tracts obscures this fact. Second, the significance of these differences is diminished further by the uncertainties in the cancer risk estimates—uncertainties in the data are also about a factor of two.<sup>40</sup> Ultimately, this is of secondary importance because the differences in cancer risks between jurisdictions are far less important than the relative contributions of each source category within them. Third, the cancer risk estimates do not include diesel PM,<sup>41</sup>

which is generated largely by mobile sources and is a major, and often the largest, source of cancer risks in urban areas.<sup>42</sup>

Notwithstanding these qualifications, the 2005 NATA estimates of cancer risk reinforce the evidence showing that mobile and nonpoint sources are the primary contributors in most counties and census tracts. This pattern should not obscure the fact that the absolute levels of cancer risks associated with industrial sources can be very high on their own—for the most severely impacted areas, cancer risks substantially higher than 20 per million. Industrial sources therefore cannot be overlooked if EPA and the states are to succeed in reducing cancer risks below the Agency's regulatory target of one per million.<sup>43</sup>

### 3. The Challenge of Neighborhood-Scale Hotspots

The EPA emissions inventories and cancer-risk data are limited to spatial scales of counties or census tracts. Counties typically range in area from tens to more than 1,000 square miles. Census tracts can also vary considerably in size, particularly in rural areas, but in cities, they generally cover areas of about two square miles.<sup>44</sup> For purposes of modeling the movement and concentrations of air pollutants, obtaining a resolution below one square mile is quite challenging if the objective is to estimate air pollution levels from all sources across a metropolitan area.<sup>45</sup> However, recent studies of air pollution emanating from highways have shown that hotspots of air toxics can be localized at spatial scales of several hundred meters.<sup>46</sup>

A potential problem with the EPA data is that localized hotspots can be obscured when the emissions associated with them are averaged over the much larger areas that census tracts and counties encompass. EPA acknowledges

38. In terms of absolute emissions, there are roughly 2,850 facilities nationally that emit more than 1,000 lbs. of carcinogens per year (about three lbs. per day), and they are located in about 2,250 census tracts.

39. Of the thousand census tracts with the highest cancer risks, 557 are located in the Los Angeles and 342 are in the New York metropolitan areas; together, the two cities encompass 90% of the top 1,000 tracts.

40. NATA OVERVIEW, *supra* note 18, at 71-77.

41. U.S. EPA, SUMMARY OF RESULTS, *supra* note 37, at 1.

42. Rachel Morello-Frosch & Bill M. Jesdale, *Separate and Unequal: Residential Segregation and Estimated Cancer Risks Associated With Ambient Air Toxics in U.S. Metropolitan Areas*, 114 ENVTL. HEALTH PERSP. 386, 389 (2006).

43. See CAA, 42 U.S.C. §7412(f)(2) (2006).

44. NATA OVERVIEW, *supra* note 18, at 27-28.

45. See *supra* notes 25-28 and accompanying text.

46. *Id.*

explicitly that its cancer risk data lack the resolution necessary to detect neighborhood-scale hotspots, and it notes that cancer risks within a census tract can vary by a factor of ten.<sup>47</sup> The potential therefore exists for many hotspots to exist, albeit spatially constrained and population-limited, that are not captured by the EPA data. If accurate, the low resolution of the EPA data would present a misleadingly positive picture of the risks from industrial emissions of air toxics.

The data available to test this hypothesis are quite limited. The technical limitations of existing air pollution models and the high costs of operating high-resolution monitoring networks are the primary impediments. Some of the best scientific work on microscale hotspots has been conducted in Corpus Christi, Texas, which is home to several major petroleum refineries and a virtually unique network of monitors for collecting high-quality measurements.<sup>48</sup> The results of this work are encouraging. Overall, the researchers found that the average annual ambient levels of air toxics (e.g., benzene, butadiene) were below the state regulatory limits.<sup>49</sup> Moreover, the direct measurements of air toxics were complemented by high-resolution modeling studies.<sup>50</sup>

These results are obviously not representative of other industrial facilities—particularly steel mills and foundries—but they do provide a useful benchmark for assessing whether microscale hotspots are likely to be significant around major sources of air toxics. Refineries are among the largest industrial facilities in the country and a leading industrial source of air toxics. The modeling results in Corpus Christi are also consistent with estimates of cancer risks from air toxics emitted by industrial facilities (including refineries) in California.<sup>51</sup>

The results of existing monitoring data are far from definitive. They are nevertheless suggestive that the limited spatial resolution of the EPA data is unlikely to be a major source of error for assessing whether pollution trading regimes are likely to exacerbate toxic hotspots. Of equal importance, rough measures can be used to identify facilities that could pose problems and therefore would warrant greater attention and monitoring, and they suggest that the potential universe of facilities is relatively small.<sup>52</sup> More work is clearly needed to help resolve these uncertainties and would be of great

value to communities located along the fence lines of major industrial facilities.

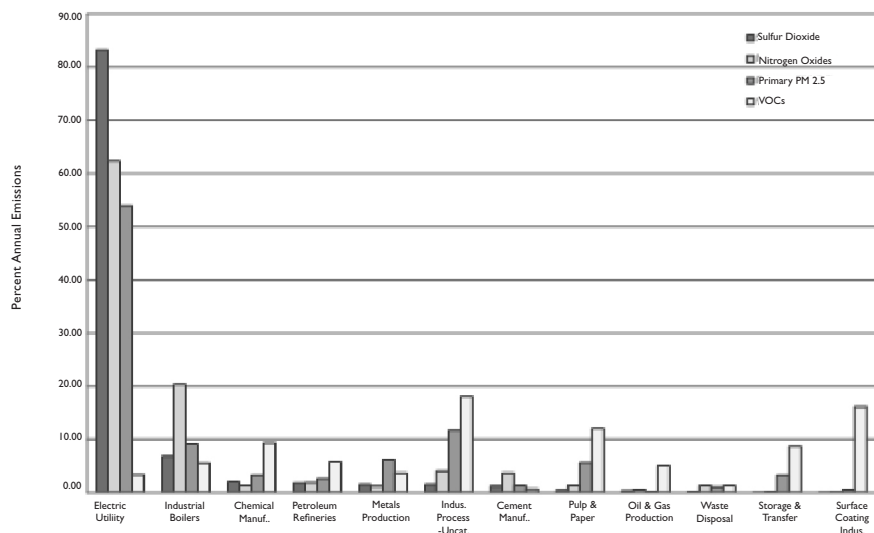
## II. Reassessing the Debate Over Pollution Trading and Hotspots

The EPA data provide a global picture of the major sources of air toxics and their geographic distribution. The small relative contributions of industrial facilities and dominance of nonpoint and mobile sources are evident in all of the empirical studies. These patterns recur whether one evaluates source contributions in terms of emissions levels or cancer risks, and they persist at geographic scales ranging from census tracts to the nation as a whole.

An important implication of these findings is that air pollution generated by many small sources—because they are inherently diffuse—is less likely to be concentrated in certain neighborhoods.<sup>53</sup> Further, while disparities in pollution levels do and will continue to exist, the data suggest that the specific types of contributing sources will vary substantially across jurisdictions. Above all, the EPA data show that reductions in emissions from small businesses, the transportation sector, and residential sources will be critical to lowering levels of air pollutants, which by any measure remain high in urban areas where more than 80% of the U.S. population lives.<sup>54</sup>

The analysis in this section of the potential for hotspots to arise under a pollution trading program will focus on

**Figure 4: Relative Emissions of Criteria Pollutants by Industry 2005**



47. *Id.*

48. Adelman, *supra* note 27, at 300-03.

49. *Id.*

50. *Id.*

51. *Id.* at 318.

52. Using the Corpus Christi facilities as a benchmark for emissions levels that could cause microscale hotspots, the number of facilities with comparable emissions of air toxics is roughly in the range of 750 to 1,400. *Id.* at 302. This is a significant number of facilities, but still very tractable relative to the number of major sources nationally.

53. Localized concentrations of small sources (such as congested highways), however, can be and are associated with urban hotspots. *See supra* notes 19 & 43.

54. PAUL MACKUN & STEVEN WILSON, POPULATION DISTRIBUTION AND CHANGE: 2000 TO 2010, at 4 (2011), available at <http://www.census.gov/prod/cen2010/briefs/c2010br-01.pdf> (stating that almost 84% of the U.S. population lives in urban metropolitan areas).

air toxics. There are several reasons for focusing on them. Perhaps the most important one is that concerns about hotspots have revolved around air toxics because they are believed to pose the greatest localized risks. More practically, the data on criteria pollutants are limited both in type (geospatial data on risks are not available) and resolution (the data are limited to the county level). Substantive reasons also exist for being less concerned about hotspots involving criteria pollutants. Figure 4 below reveals that electric utilities, particularly coal-fired power plants, emit a majority of the key criteria pollutants and yet direct monitoring shows that they have not caused localized hotspots.<sup>55</sup> Further, PM<sub>2.5</sub> is the most potent criteria pollutant, but apart from electric utilities, its emissions are spread broadly across industrial sectors that collectively account for only about 8% of aggregate emissions. These patterns demonstrate that, consistent with conventional wisdom, focusing on emissions of air toxics will capture the upper bound of the risk that pollution trading could cause hotspots.

Despite the strength and consistency of these broad patterns, jurisdictions exist in which industrial sources account for a large fraction of total toxic air emissions, cancer risks, or both. The potential for localized hotspots in these jurisdictions cannot be foreclosed. For purposes of this discussion, a census tract will be treated as an “industrial hotspot” if point-source emissions produce cancer risks of at least 20 per million *and* account for a minimum of 30% of the cumulative cancer risks across the tract. The cancer risk cutoff is intended to be conservative—it is a factor of 20 above EPA’s target risk level and a factor of five below the cancer risk EPA deems to be clearly unacceptable<sup>56</sup>; it is also less than one-half of the 50-per-million national average for cancer risks from air toxics.<sup>57</sup>

### A. The Scarcity of Industrial Hotspots Nationally

Among the 65 census tracts with the highest relative risks from industrial emissions of air toxics, industry accounted on average for 60% of the cumulative cancer risks. In these tracts, disparities in industrial emissions would be discounted on average just 40%. As a consequence, local disparities in emissions from industrial sources are unlikely to be overwhelmed by emissions from other sources. Further, the high proportion of emissions from industrial sources elevates the significance of errors in EPA risk estimates, as they too are less likely to be obscured. These factors lead

to a straightforward inference: pollution trading-induced hotspots will occur, if at all, in jurisdictions defined here as industrial hotspots.

Two hundred and forty census tracts out of 65,000 nationally satisfied my definition of an industrial hotspot in 2005.<sup>58</sup> They were spread across 73 counties located in 26 states, but were most prevalent in Pennsylvania (71), Ohio (25), Indiana (23), Kansas (15), Texas (15), and Alabama (13). Industrial hotspots were closely associated with steel mills and foundries, about 200 tracts or 80% of the total, and the primary pollutants were chromium (99 tracts) or coke oven emissions (96 tracts).<sup>59</sup> Among the 65 census tracts in which point sources accounted for more than one-half of the cumulative cancer risk, only one in Houston, Texas, and another in Lincoln, Nebraska, were associated with other types of emissions.<sup>60</sup> Further, all but the census tracts in Pittsburgh, Birmingham, and Houston, which each were outliers with respect to the volume or toxicity of their industrial emissions,<sup>61</sup> were located in rural communities or mid sized cities.

Industrial hotspots were closely associated with highly toxic industrial emissions and low—relative to major urban areas—emissions from mobile and nonpoint sources. Industrial sources rarely dominated emissions from the other source categories, apart from these exceptional circumstances. Setting aside the distinctive conditions in Birmingham, Houston, and Pittsburgh, this phenomenon effectively forecloses industrial hotspots in large urban areas.

The demographics of the census tracts with industrial hotspots are notable because they were bimodal. This pattern follows from the split between the geographic centers for steel production in the southern states and those in and around Pittsburgh. In 2005, the demographics of communities with steel mills were on average 24% minority, whereas the percentage for iron and steel foundries was 41%; both were located in communities in which 17% of the population was low-income.<sup>62</sup> By comparison, minorities made up 32% of the U.S. population, and low-

55. See *supra* notes 10-11 and accompanying text. Electric utilities do not dominate emissions of VOCs, but they are precursors of ozone, which, because its generation requires atmospheric mixing and subsequent chemical reactions, is inherently far less prone to being associated with localized hotspots.

56. In California, for example, regulatory action is also triggered when a facility’s cancer risk exceeds 10 per million. S. COAST AIR QUALITY MGMT. DIST., ANNUAL REPORT ON AB 2588 AIR TOXICS “HOT SPOTS” PROGRAM 2-3 (2011), available at [http://www.aqmd.gov/prdas/ab2588/pdf/Annual\\_Report\\_2010.pdf](http://www.aqmd.gov/prdas/ab2588/pdf/Annual_Report_2010.pdf).

57. U.S. EPA, SUMMARY OF RESULTS, *supra* note 37, at 5. This definition provides a rough margin of error beyond the putative factor-of-two uncertainty in EPA’s risk estimates, as the cancer risks from industrial sources not located in hotspots would still fall substantially below the national average if EPA’s estimates were off by this amount.

58. The number of industrial hotspots may be declining as a consequence of more stringent standards for steel mills and foundries that EPA issued in 2005 and 2007. See, e.g., National Emission Standards for Hazardous Air Pollutants for Iron and Steel Foundries, 73 Fed. Reg. 7210 (Feb. 7, 2008) (codified at 40 C.F.R. pt. 63); National Emission Standards for Hazardous Air Pollutants for Coke Ovens: Pushing, Quenching, and Battery Stacks, 70 Fed. Reg. 44285 (Aug. 2, 2005) (codified at 40 C.F.R. pt. 63). Emissions of chromium compounds from steel plants in Alabama, Indiana, Ohio, and Pennsylvania (the states with the bulk of the industrial hotspots), collectively declined 50% between 2005 and 2010.

59. Both chromium and coke oven emissions have high relative toxicities. Adel M. Zayed & Norman Terry, *Chromium in the Environment: Factors Affecting Biological Remediation*, 249 PLANT & SOIL 139, 141 (2003) (describing chromium VI as an “extremely toxic” compound).

60. In Houston, it was benzene and butadiene from refineries and chemical plants, but in Lincoln, it was naphthalene from commercial boilers. The 2005 NATA data do not identify the chemical compounds responsible for the high risks from industrial sources in the other seven census tracts.

61. Houston was an outlier as we have seen with regard to the volume of its industrial emissions; Pittsburgh and Birmingham were outliers with respect to the toxicity of emissions from local steel mills and foundries.

62. Michael Ash et al., JUSTICE IN THE AIR: TRACKING TOXIC POLLUTION FROM AMERICAN’S INDUSTRIES AND COMPANIES TO OUR STATES, CITIES, AND NEIGHBORHOODS 6-8 (2009), available at <http://www.peri.umass.edu/justice/>.



income individuals accounted for 13%.<sup>63</sup> Minorities were thus overrepresented in communities with iron and steel foundries, but underrepresented in communities with steel mills, whereas the low-income percentages were close to the national averages in both cases.<sup>64</sup>

The disparities for minority populations living around steel mills and foundries arguably cut both ways.<sup>65</sup> If an average is calculated for steel mills and foundries collectively, the value for the minority share of toxic exposures is 32%, which is identical to the minority share of the population nationally.<sup>66</sup> If the results are disaggregated, however, one could conclude that iron and steel foundries disproportionately impact minority communities.

As a practical matter, disagreements about the geographic area over which inequities are evaluated are probably secondary. Other factors are likely to preclude pollution trading programs from exacerbating environmental inequities. Much will turn on the economics of emissions reductions and the specific targets for reducing emissions. If the former are favorable, as they were for the SO<sub>2</sub> trading regime, disparities simply will not arise. To the extent that the latter are modest, say 30% over one decade, this would create an upper bound on potential disparities, which would then be discounted by the average relative contribution of industrial sources in the census tract. This would result, for example, in an upper bound for disparities among the highest risk census tracts of 18% or, in absolute terms, an increase in cancer risk on average of approximately 12 per million for the top 65 census tracts or about five per million for the 240 tracts defined here as industrial hotspots.<sup>67</sup>

However one aggregates the data, they indicate that the potential is low for pollution trading programs to cause racial or income-based inequities in exposures from air toxics and that if hotspots were to materialize, they would be limited to a small number of census tracts. The data also show that large populations and high population densities all but foreclose the emergence of industrial hotspots in metropolitan areas where the cancer risks from air toxics are often highest. It is my hope that the EPA data and preceding analysis will assuage concerns that toxic hotspots are an inevitable byproduct of adopting pollution trading regimes. More broadly, I hope that this work will lower health-equity concerns about market-based regulations generally—including taxes. The public is nevertheless likely to demand that additional measures be taken to ensure that

communities located in industrial hotspots are adequately protected; the next section addresses these concerns.

## B. Resolving the Tensions Between Equity and Efficiency in Pollution Trading Programs

The preceding analysis has shown that inequities cannot be foreclosed in jurisdictions for which industrial sources contribute significantly to toxic emissions. Further, risk estimates in these jurisdictions will be more sensitive to the acknowledged uncertainties in the EPA data, which could fuel skepticism about the metrics—particularly cancer risks—upon which the preceding analysis is based. The remaining uncertainties, as well as the prospect of using pollution trading programs to achieve dramatic reductions in air pollution, are likely to prompt calls for additional legal protections to safeguard potentially vulnerable communities.

Adapting pollution trading regimes to prevent the emergence of toxic hotspots has been a contentious issue from the start.<sup>68</sup> Proponents of market-based regulations worry that mechanisms for addressing inequities will sacrifice the efficiency of pollution markets by either increasing transaction costs or placing restrictions on the trades that can occur (e.g., geographic limits).<sup>69</sup> The debate then becomes one of balancing the efficiency of pollution markets against distributional concerns about environmental inequities—although few studies have attempted to assess the potential for pollution trading regimes to generate significant environmental inequities.<sup>70</sup>

The geographically discrete nature of industrial hotspots described above suggests that a targeted strategy for mitigating potential inequities ought to be feasible. This approach would have two obvious benefits. First, it would avoid the added costs of imposing additional measures on the entire system, which for a national market would be considerable. Second, the small number of jurisdictions involved would enable refinement of legal mechanisms in the relevant jurisdictions without materially impacting the administrative costs of the program.

63. *Id.*

64. Although the study does not provide this number explicitly, the minority average for all industries was approximately 15%. *See id.*

65. Basic statistics tells us that the variance in racial composition will increase as the geographic scale is decreased. Accordingly, the observed siting patterns could be consistent with a random distribution of facilities.

66. The minority share for steel mills and iron and steel foundries was 24% and 41%, respectively. *Id.* If the two numbers are averaged by weighting them according to their respective toxic score, collectively, the minority share is 32%, which is essentially identical to the minority share of the U.S. population. *See id.* at 10-11.

67. These estimates are based on the average cancer risks associated with industrial sources in industrial hotspots; I have simply multiplied the average cancer risk by the percentage disparity.

68. Nash & Revesz, *supra* note 1, at 572 (stating the proposals to mitigate hotspots have had “significant drawbacks, either providing only an incomplete solution to the problem or introducing complexity that could stand in the way of the efficient functioning of the market”); Alan J. Krupnick et al., *On Marketable Air-Pollution Permits: The Case for a System of Pollution Offsets*, 10 J. ENVTL. ECON. & MGMT. 233, 242-43 (1983) (discussing the trade offs between efficiency and spatial disaggregation of a market to accommodate geographic and other variables in the area covered by a trading program).

69. *See, e.g.*, U.S. EPA, TOOLS OF THE TRADE: A GUIDE TO DESIGNING AND OPERATING A CAP AND TRADE PROGRAM FOR POLLUTION CONTROL 3-22 (2003) (discussing the trade offs between efficiency and distributional concerns).

70. *See* Manuel Pastor et al., MINDING THE CLIMATE GAP: WHAT’S AT STAKE IF CALIFORNIA’S CLIMATE LAW ISN’T DONE RIGHT AND RIGHT AWAY 21-22 (2010) (finding that a GHG trading program in California could cause hotspots around certain facilities that result in environmental inequities); SCHATZKI & STAVINS, *supra* note 7, at 15-18 (using air pollution data for Los Angeles to argue that hotspots are unlikely to arise from a GHG trading program in California); Ringquist, *supra* note 4, at 301-02, 321-22 (describing the handful of existing studies that exist; finding a negative correlation between the minority status of local communities and the likelihood that a facility would purchase emissions credits in the SO<sub>2</sub> trading program).

I will not attempt to describe the details of how pollution trading programs could be modified in this Article. My central point is simply that the trade off between equity and efficiency is largely neutralized by the infrequency of industrial hotspots nationally. In addition, a large literature exists on modifying pollution trading regimes to prevent the emergence of toxic hotspots,<sup>71</sup> and there is every reason to believe that these policies would work well under circumstances where hotspots are rare. In the analysis that follows, I assume that targeted policies would apply only to sources with large emissions of the traded pollution (or closely correlated co-pollutants) located in census tracts meeting my definition of industrial hotspot.<sup>72</sup>

To illustrate the feasibility of mitigating toxic hotspots, I will briefly describe three prominent mechanisms for modifying pollution trading regimes in the literature. The examples are (1) heightened monitoring and informational requirements for trades, (2) geographic restrictions on trading (often referred to as “zonal trading”), and (3) pollution offset markets in which sales of credits to sources located in industrial hotspots would be subjected to a premium (i.e., greater than a one-to-one ratio of credits per unit of emissions).<sup>73</sup> My primary purpose in discussing these policies is to highlight the increased efficacy and administrative ease of implementing them when the number of potential hotspots is small. I will briefly describe each of the strategies and then highlight how they benefit from a targeted approach.

Heightened monitoring and informational requirements could be imposed in a variety of ways. At minimum, they could involve reporting the increased emissions of the pollutants being traded (or associated co-pollutants). As a purely informational approach, this would minimize transaction costs, which could be further reduced by using EPA emissions factors to calculate emissions differentials. More elaborate requirements could include added monitoring requirements in and around facilities, as well as high-resolution modeling of the impacts on local pollutant levels and risks. In other words, facilities wishing to purchase credits could be required to provide high-quality information on the local impacts of their proposed trades and to make this information available to the public. These added requirements would increase the effective cost of emissions credits

and potentially lead to public pressure, both of which would reduce the attractiveness of purchasing emissions credits.

A virtue of an approach that singles out higher risk facilities is that the information would be required only where it would be most valuable. Nor would these requirements lead to an unmanageable amount of new information that could be difficult for either EPA or the general public to absorb and utilize effectively. Imposing elevated standards selectively could also have spillover benefits. For example, higher quality information on emissions from targeted facilities could be used to improve emissions inventories and risk estimates for facilities elsewhere, and this information could in turn be used to set priorities for clean air regulations.

Geographic restrictions on pollution trading have long been discussed as a strategy for protecting against hotspots under cap-and-trade regimes.<sup>74</sup> They often take the form of strict limits on trades between geographically delimited zones within a trading area.<sup>75</sup> For example, the pollution trading program in southern California (RECLAIM) has two zones (one coastal and one inland); it bans trades that could increase pollutant levels in the more-industrialized coastal zone.<sup>76</sup> Numerous variations exist on this basic strategy, including highly calibrated systems that restrict trades if they could “lead[ ] to a violation of an ambient standard at any receptor point.”<sup>77</sup> Regardless of the specifics, restrictions on pollution trading cover specified sources or trades and are designed to prevent increases in aggregate emissions in a particular geographic zone.

The EPA emissions and cancer risk data provide reliable metrics for identifying the geographic zones (e.g., the 240 census tracts noted above) in which trading might be restricted under a pollution trading system. Further, the distinctive characteristics of industrial hotspots in the United States ought to simplify implementation of such restrictions as most of them are caused by a single, or small number of, facilities. They are also located predominantly in rural areas and small cities, which means that few, if any, other sources would be affected by targeted restrictions on trading. The most significant exceptions would be Houston and, to a lesser extent, Pittsburgh and Birmingham, but precedent exists for pollution trading even in cities as large as Los Angeles.

The third mechanism, pollution offsets, can be structured around specific classes of facilities or geographic zones. For example, either steel mills alone or all facilities within a certain radius of a steel mill could be subjected to a premium for purchasing emissions credits (e.g., required to purchase two credits for every ton of the traded pollutant). Furthermore, the tractable numbers could allow offset ratios to vary according to the risks posed by co-pollutants in the associated area. These measures could be combined with the heightened monitoring requirements discussed

71. See, e.g., Chinn, *supra* note 1, at 115-22; Drury et al., *supra* note 2, at 284-88; Meredith Fowle & Nicholas Muller, *Designing Markets for Pollution When Damages Vary Across Sources: Evidence From the NO<sub>x</sub> Budget Program 2-4* (U.C. Berkeley & Nat'l Bureau of Econ. Research, 2010), available at <http://ei.haas.berkeley.edu/pdf/seminar/Seminar20111202.pdf>; Evan Goldenberg, *The Design of an Emissions Permit Market for RECLAIM: A Holistic Approach*, 11 UCLA J. ENVTL. L. & POL'Y 297, 313-17 (1993); Johnson, *supra* note 2, at 147-64; Kaswan, *supra* note 5, at 10304-07; Krupnick et al., *supra* note 68, at 238-42; Nicholas Z. Muller & Robert Mendelsohn, *Efficient Pollution Regulation: Getting the Prices Right*, 99 AM. ECON. REV. 1714, 1735-37 (2009); Nash & Revesz, *supra* note 1, at 572-73; Tom Tietenberg, *Tradeable Permits for Pollution Control When Emission Location Matters: What Have We Learned?*, 5 ENVTL. & RESOURCE ECON. 95, 103-10 (1995).

72. The definition of industrial hotspots need not be identical to mine, but it must be defined in absolute terms (minimum cancer risk) and relative terms (percentage of cumulative cancer risks attributable to industrial sources).

73. See, e.g., Nash & Revesz, *supra* note 1, at 614-15.

74. See *supra* note 69.

75. *Id.*

76. Specifically, new sources and existing sources seeking to exceed their initial allocation of emissions can only purchase credits within the coastal zone. Nash & Revesz, *supra* note 1, at 611-12.

77. *Id.* at 624-25.

above, each of which would increase the effective cost of emitting the traded pollutant and thus enhance incentives to reduce emissions directly.

The relative ease of implementing a pollution-offset program when the number of facilities or jurisdictions is small mirrors that for the heightened monitoring and information requirements. When delimited geographically, pollution offsets share many similarities with zonal programs, the primary difference being that premiums are imposed rather than rigid restrictions on trades. For a pollution-offset program, arguably the greatest benefit of the scarcity of potential hotspots is that the offsets could be set for specific facilities or jurisdictions and be optimized over time. By contrast, the limits of administrative capacities for such refinements would be drastically reduced if the numbers were large.

This brief discussion of legal mechanisms is merely intended to highlight several of the practical benefits of being able to readily identify and characterize the small number of industrial hotspots potentially at risk under a pollution trading program. The primary virtues are straightforward: addressing potential inequities would be very unlikely to impact the efficiency of a national or state-level trading market, and the tractable numbers would enable accurate monitoring as well as optimization of legal mechanisms over time.

### III. Conclusions

This Article provides an overview of EPA emissions inventory and cancer risk data for criteria pollutants and air toxics in the United States. The data show clearly that vehicles and small stationary sources emit a majority of the air pollution nationally and account for most of the cancer risks from air toxics. This pattern is replicated at spatial scales ranging from census tracts to the nation as a whole. It is most pronounced, however, in large metropolitan areas, which have the lowest air quality and are home to 80% of the U.S. population. In some rural and small-urban areas, industrial facilities can account for a higher proportion of air toxics, but this occurs in fewer than 250 census tracts nationally and is closely associated with a handful of industries.

The secondary status of industrial facilities as sources of air pollution largely neutralizes the potential for pollution trading programs to cause hotspots. In the vast majority of jurisdictions, industrial emissions are simply too low, and in the few jurisdictions in which disparities cannot be ruled out, targeted policies exist to prevent them without compromising market efficiency. These findings are generalizable to all market-based regulations.