

# Sneezing and Wheezing:

How Climate Change Could Increase Ragweed Allergies, Air Pollution, and Asthma

AUTHORS:

Juan Declet-Barreto, Ph.D.

Sean Alcorn

*Natural Resources  
Defense Council*

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*NRDC Director of Communications:* Lisa Benenson

*NRDC Deputy Director of Communications:* Lisa Goffredi

*NRDC Policy Publications Director:* Alex Kennaugh

*Design and Production:* [www.suerossi.com](http://www.suerossi.com)

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## EXECUTIVE SUMMARY

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2014 was the hottest year on Earth since recordkeeping began in 1880, and ten of the previous warmest years on record occurred since 2000.<sup>1</sup> The scientific consensus is that climate change is the driving force behind these rising temperatures. Scientific studies have also shown that our changing climate could favor the formation of more ozone smog in some areas and increase the production of allergenic pollen such as that released by the ragweed plant, the principal source of pollen associated with allergic rhinitis.<sup>2</sup> This is bad news for allergy sufferers and asthmatics because both ragweed pollen and high levels of ozone smog can trigger asthma attacks and worsen allergic symptoms in adults and children. Moreover, studies show that people exposed to both ragweed allergens and ozone are likely to become more ill than people exposed to just one of the two.<sup>3</sup> These negative health effects are expected to worsen if carbon dioxide (CO<sub>2</sub>) concentrations keep rising and climate change continues unchecked.

In order to understand the scope of this problem and who will be affected by it, the Natural Resources Defense Council has updated its groundbreaking 2007 “Sneezing and Wheezing” report, which mapped, for the first time, areas within the United States where ragweed and unhealthy ozone pollution overlap. This new report shows that one-in-three Americans, 109 million people in our country, are the most exposed to worsening respiratory allergies and asthma associated with climate change. In fact 34 out of the top 50 “Asthma Capitals 2014” identified by the Asthma and Allergy Foundation of America are in counties where both problems occur.<sup>4</sup> The Top 10 Sneeziest and Wheeziest cities in the United States are Richmond, Memphis, Oklahoma City, Philadelphia, Chattanooga, Chicago, Detroit, New Haven, Allentown and Atlanta. (See Appendix B: Sneeziest and Wheeziest Cities 2014.) While these urban areas rank as the worst for both ragweed and high ozone levels, the most vulnerable regions nationally are the Los Angeles Basin, the region around St. Louis, the Great Lakes area, the Mid-Atlantic States, and New England. Together, the findings that so many Americans face this double-whammy health risk provide evidence of the urgent need for taking action now to reduce the health threats posed by climate change.

### **ALLERGIES AND ASTHMA: SERIOUS HEALTH THREATS ON THE RISE**

An estimated 50 million Americans today have some type of nasal allergy. In 2012, an estimated 7.5 percent of adults and 9.0 percent of children were diagnosed with seasonal allergic rhinitis (or hay fever), whose symptoms include inflammation and irritation of the nose, sinuses, throat, eyes, and ears as well as sneezing, runny nose, and itchy eyes.<sup>5,6,7</sup> Allergies can seriously affect health as well as educational and business productivity: It is estimated that more than 3.8 million work and school days are missed each year due to seasonal ragweed pollen allergies.<sup>8</sup> In many industrialized countries like the United States, there is evidence that respiratory allergic diseases are increasing in prevalence and severity, and some studies suggest that people in cities are more likely to experience allergy symptoms than those living in rural areas.<sup>9,10,11</sup>

In 2011, some 26 million children and adults in the United States had asthma, a chronic lung disease in which air passages become inflamed and constricted, making breathing difficult.<sup>12,13</sup> Of this number, 7.1 million were under 18 years of age, and 13.2 million had at least one asthma





## PICTURE THIS

Twenty years in the future, the “dog days” of August and September bring still, cloudless weather that increases peak ozone concentrations. At the same time, heightened CO<sub>2</sub> emissions from the burning of fossil fuels and blazing temperatures fueled by climate change have created the perfect conditions for ragweed pollen production. Particularly in and around cities, where the urban heat island effect boosts temperatures and ragweed thrives in the disturbed soils of vacant lots and building sites, people who suffer from allergies and asthma will be stricken with a host of debilitating symptoms. Thanks to the potential for weeds, grasses, and trees to increase the intensity and length of the allergy season, worsening air quality on hotter days, and increased asthma attacks from ozone smog in the air, our health will likely suffer in a warming world.

attack. While some asthma symptoms can be treated, the disease cannot be cured. Allergies are among the factors that can trigger an asthma attack, and it is believed that worldwide, about 70 percent of asthmatics also have allergic rhinitis.<sup>14</sup> Research has found that the prevalence of asthma increases among individuals with rhinitis, lending support to the hypothesis that allergies may exacerbate asthma risks.<sup>15,16</sup>

In the United States, asthma prevalence increased from about 20 million in 2001 (7 percent of the population) to almost 26 million in 2010 (8.4 percent of the population).<sup>17</sup>

## CLIMATE CHANGE WORSENS RESPIRATORY HEALTH

The severity of both allergies and asthma is closely linked to environmental conditions, particularly air quality.<sup>18</sup> Climate change and rising CO<sub>2</sub> levels are projected to worsen air quality and could threaten human health in many areas due to increased levels of allergenic pollen and ground-level ozone.<sup>19</sup> Scientific studies have found that allergenic pollen production increases as CO<sub>2</sub> concentrations and temperatures climb. For example, ragweed plants have been shown to grow bigger and produce more pollen when levels of CO<sub>2</sub> increase and to produce pollen for longer seasons.<sup>20,21</sup> These plants have also shown increased tolerance to high ozone levels.<sup>22,23</sup>

## GOVERNMENT AGENCIES MUST PROTECT COMMUNITIES FROM THE HEALTH EFFECTS OF CLIMATE CHANGE DRIVEN BY CARBON POLLUTION

Many of the sources of ozone-producing chemicals—industrial facilities, electric power plants, and motor vehicles—also emit the carbon pollution that drives climate change. Therefore, minimizing emissions from these sources can help reduce ozone air pollution and climate change, helping to create better air quality conditions today and a cooler, healthier environment in the future. In the summer of 2015, the U.S. Environmental Protection Agency (EPA) is expected to finalize the Clean Power Plan, which will establish the first-ever national limits on carbon pollution from power plants—currently the largest source of carbon pollution in the United States. The Clean Power Plan is a major step forward to curb climate change and to reduce emissions that create ground-level ozone.

# OZONE CONCENTRATIONS AND RAGWEED OCCURRENCE LIKELY TO INCREASE WITH CLIMATE CHANGE

Levels of ozone and pollen allergens are likely to increase under climate change. Ragweed pollen, for example, tends to increase with higher CO<sub>2</sub> concentrations, and warmer summertime temperatures increase ozone levels in many areas.<sup>24</sup> Hot, clear summer days with calm winds tend to increase both ozone and pollen concentrations. Atmospheric CO<sub>2</sub> levels have increased by 27 percent since 1960, up from just under 315 parts per million (ppm) to the current estimate of 400 ppm.<sup>25</sup> In the United States, average temperatures since 1895 have increased by 0.72°C to 1.1°C (1.3°F to 1.9°F), and projections indicate that temperatures will rise another 1.1°C to 2.2°C (2°F to 4°F) across most areas of the United States in the coming decades.<sup>26</sup> These observed and predicted trends mean that many more hot days will be in store in the future.

## MAPPING THE MOST VULNERABLE REGIONS

Because there is evidence that exposure to unhealthy levels of ozone can damage the lungs and worsen allergic responses to pollen allergens, NRDC has identified those areas of the United States where ragweed and ozone problems intersect.<sup>27</sup> Although ragweed is not the only source of pollen allergens, we focus on ragweed in this report due to its well-known association with allergic rhinitis.<sup>28</sup> Using a Geographic Information System (GIS), we overlaid the areas that experience an average of one or more days per year of unhealthy ozone conditions on a base map showing U.S. counties where ragweed has been reported. As shown in Figure 1, there are 275 counties in the United States—home to 109 million people—that experience both ragweed pollen and unhealthy ozone days. Together, the ragweed pollen and ozone can interact to worsen respiratory health, making these areas especially vulnerable to a climate change-related rise in allergic and respiratory disease.

**Figure 1. Intersection of Ragweed-Positive and Eight-Hour Ozone Exceedance-Positive Areas in the Continental United States**

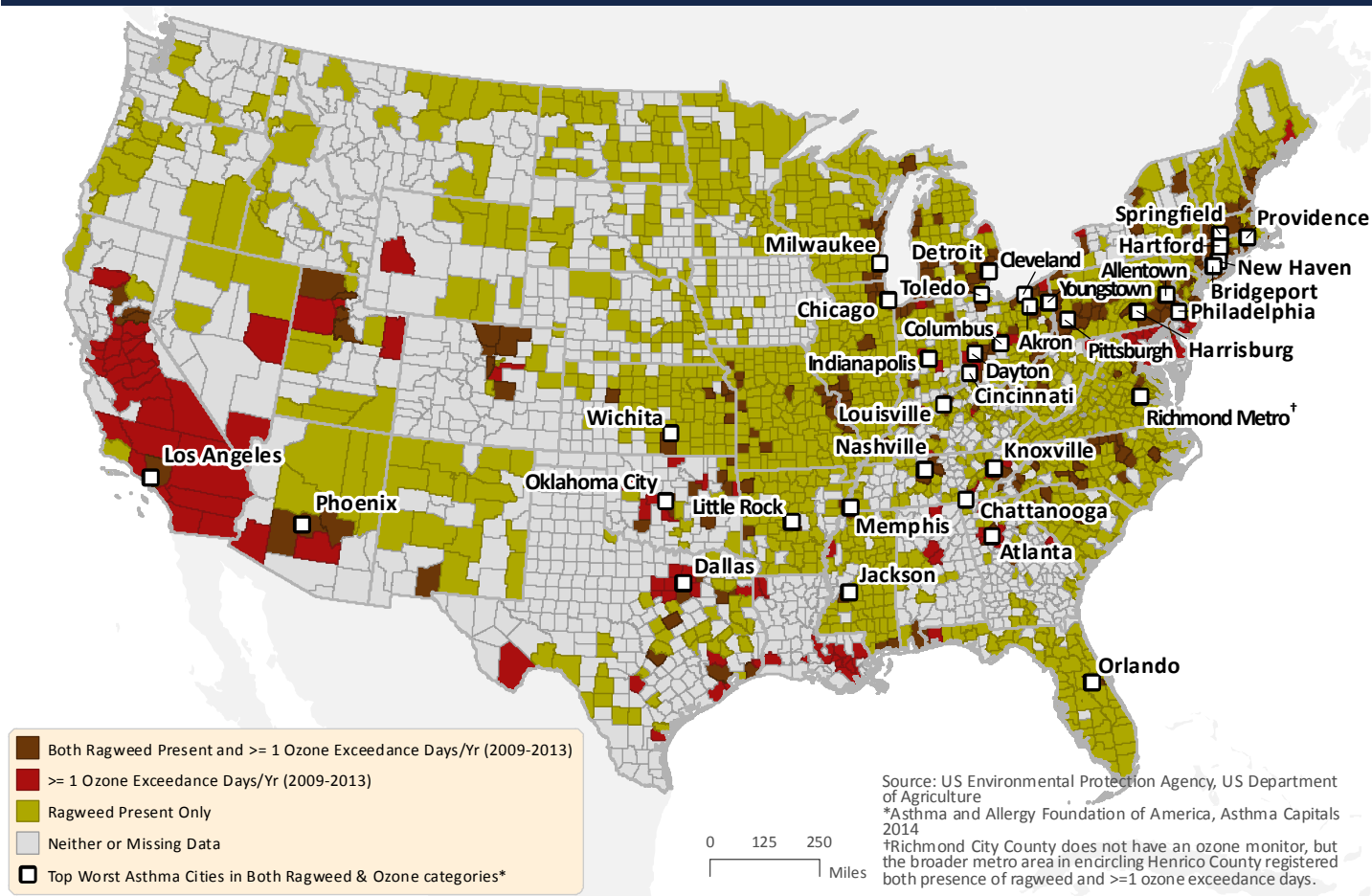


Figure 1 also shows the location of some of the top cities from the list of “Asthma Capitals 2014—The Most Challenging Places to Live with Asthma,” published by the Asthma and Allergy Foundation of America. This is one list on which being in first place is no honor: The top spot each year is reserved for the metro area with the greatest concentration of negative factors that can potentially affect asthma patients.<sup>29</sup> Thirty-four of the top 50 “asthma capitals” for 2014 are located in areas where people’s health is currently challenged by both ragweed and ozone.<sup>30</sup> Richmond, Virginia, is—for the second time in a row—number one on this list. Although Richmond does not have an ozone monitoring station and is not ragweed-positive, we include it on the map because of its status as the number one Asthma Capital. As temperatures warm and CO<sub>2</sub> concentrations increase further with climate change, ragweed and ozone conditions could become even more severe.

## HOW OZONE IS HAZARDOUS TO YOUR HEALTH

Ozone (one of the main components of ground-level smog) is an irritant that inflames the lungs.<sup>31</sup> Health effects related to ground-level ozone exposure include increased respiratory symptoms, damage to cells of the respiratory tract, lung inflammation, diminished lung function in healthy adults, and exacerbation of asthma.<sup>32</sup> These illnesses often lead to increased school absences and a rise in hospital admissions for respiratory ailments and emergency room visits.<sup>33,34,35,36,37,38,39</sup> Millions of Americans live in areas where ozone concentrations exceed the U.S. EPA eight-hour regulatory limit.<sup>40</sup> And in fact, the EPA Scientific Advisory Board, public health organizations, medical societies, and patient advocacy groups have recommended lowering this limit because it is not sufficiently protective of health.<sup>41,42</sup>

Ozone can worsen allergic reactions and impair lung function, especially among children, the elderly, and people already suffering from asthma.<sup>43</sup> Even at relatively low levels, air pollution, including ozone, has been related to breathing problems and decreased lung function in asthmatic children.<sup>44</sup> And even short-term exposure to ozone can worsen asthmatic responses to allergens (such as ragweed pollen) in people with mild allergic asthma or rhinitis.<sup>45</sup>

## The Ozone and Climate Change Connection

Ozone is formed at ground level by the combination of two types of pollutants, nitrogen oxides and volatile organic compounds (VOCs), in the presence of sunlight. Warmer temperatures enhance the reactions that form ozone in the air we breathe. As a result, maximum ozone concentrations typically occur during the hot summer months.<sup>46</sup>

Vehicle exhaust and emissions from power plants and certain industrial facilities contain nitrogen oxides. Volatile organic compounds are emitted from these same sources. VOCs are also emitted by vegetation, a phenomenon enhanced by higher summer temperatures. A number of studies have projected that climate change may increase

ozone concentrations in already polluted areas.<sup>47</sup> Any increase in ozone concentrations due to climate change will further contribute to respiratory illnesses already experienced by millions of Americans.

## HOW RAGWEED POLLEN IS HAZARDOUS TO YOUR HEALTH

Many allergenic plants rely on the wind, rather than insects, to distribute their pollen. As a result, these plants must produce huge amounts of pollen in order to ensure fertilization. While most pollen grains are dispersed locally, under certain meteorological and topographical conditions, some can be carried many miles into the surrounding countryside.<sup>48</sup> Pollen surfaces contain proteins that can trigger allergic reactions. Usually the tendency to develop allergies has some genetic component, but it is common for people to develop new allergies over their lifetime. Allergies can also be caused and exacerbated by exposure to allergens and air pollutants.<sup>49</sup>

In North America, ragweed produces pollen seasonally, usually beginning after midsummer, when nights become longer.<sup>50</sup> Common ragweed (*Ambrosia artemisiifolia*) is the most widespread of ragweed species and is commonly found in open, disturbed ground around homes, in fields, along roadsides, and in vacant lots throughout the United States.<sup>51</sup> When ragweed pollen in the air enters the nose and throat of people who are allergic to pollen, it can trigger allergy and asthma symptoms. These symptoms include: runny or stuffy nose, hives, swollen eyelids and itchy eyes, and an itchy throat or ears.<sup>52</sup> Ragweed can cause hay fever and trigger asthma attacks, especially among the elderly and children.<sup>53</sup>

Pollen allergies can have even more severe health consequences for people with asthma. In one study, weed pollen levels were found to be linked to autumn peaks in children’s asthma hospitalizations.<sup>54</sup>

Common ragweed (*Ambrosia artemisiifolia*)



Source: USDA Crop Systems and Global Change Lab, Beltsville, MD.



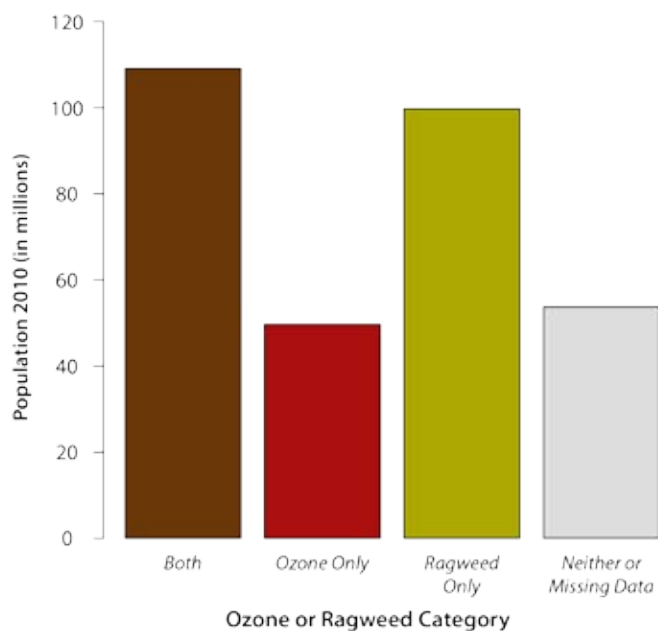
## THE RAGWEED AND CLIMATE CHANGE CONNECTION

A growing number of laboratory and field tests have shown that when there is more CO<sub>2</sub> in the environment, ragweed produces significantly more pollen.<sup>55,56,57</sup> Along with ragweed, many other pollen-producing plants, including trees such as birch, oak, and pine, tend to produce pollen earlier, for a longer time, and in greater quantities under higher CO<sub>2</sub> and temperature conditions—the kinds of conditions associated with climate change.<sup>58,59,60</sup> Weeds such as ragweed, dandelion, and poison ivy are expected to proliferate as CO<sub>2</sub> levels in the atmosphere continue to rise.<sup>61,62</sup>

Ragweed thrives in urban and suburban environments where disturbed soils are common and where vehicle and industrial emissions from fossil fuel combustion create “CO<sub>2</sub> domes” over cities.<sup>63</sup> Furthermore, temperatures tend to be higher in urbanized areas because building and pavement materials capture heat and re-radiate it more slowly than natural, vegetated areas, creating an urban heat island effect that could contribute to higher pollen and ozone production in cities.<sup>64</sup>

Figure 2 shows that in 2010 many millions of Americans lived in counties where ragweed was reported or where unhealthy ozone levels occurred. The results are sobering: Nearly 50 million Americans live in counties where ozone violates the EPA’s health-based standards at least once a year, on average (but no ragweed has been reported there), and a whopping 100 million people live in counties where ragweed has been reported (but no ozone violations have been recorded). Over 109 million Americans live in counties facing both high ozone levels and ragweed, making them the most vulnerable from these dual threats to respiratory health. The effects of climate change will likely increase both ozone levels and the proliferation of ragweed, putting exposed populations at even greater risk in the future.

**Figure 2. U.S. Population Living in Ozone or Ragweed Areas (based on U.S. Census 2010 population by county)**



### Richmond: Sneeziest and Wheeziest City

Richmond, Virginia, was named the 2014 top U.S. Asthma Capital by the Asthma and Allergy Foundation of America (AAFA). It also received this dubious distinction in 2010 and 2011. The top spot each year is reserved for the metro area with the greatest concentration of negative factors that can potentially affect asthma patients.<sup>65</sup> Contributing to Richmond’s status as the number one Asthma Capital are high pollen levels, death rates from asthma, and numbers of asthma-related emergency room visits.

Richmond is the county seat of Henrico County, which was given an F grade for ozone smog-related air quality by the 2014 American Lung Association’s *State of the Air report*.<sup>66</sup> Many people in Henrico County face ozone-related health threats: In 2012, an estimated 21,080 adults—6.7 percent of the population—were diagnosed with asthma, and 14,788 (4.7 percent) suffered from chronic obstructive pulmonary disease (COPD).<sup>67</sup> In addition, 13 percent of the population is 65 or older, and 10 percent are living in poverty. Preexisting illnesses and reduced means to obtain health care services make people more vulnerable to air pollution’s health threats.

### Many Regions Exceed EPA’s Health Standard for Ozone

Ozone levels in many areas of the country currently exceed standards set to protect public health.<sup>68</sup> Ozone is a regional pollutant, and although there are gaps in the data, existing monitoring stations show that many regions of the country experience ozone levels that could be harmful to human health (Figure 3). The EPA’s eight-hour ozone standard is exceeded on a widely varying average number of days in different regions of the United States, with a range from zero to more than 16 days per year. The regions with the highest average values are in Southern California, the Washington-Philadelphia-New York-Boston corridor in the Northeast, and cities along the southern portion of Lake Michigan. As mentioned above, more than 50 million people currently live in areas where ozone levels can be harmful, and these levels could worsen under climate change.

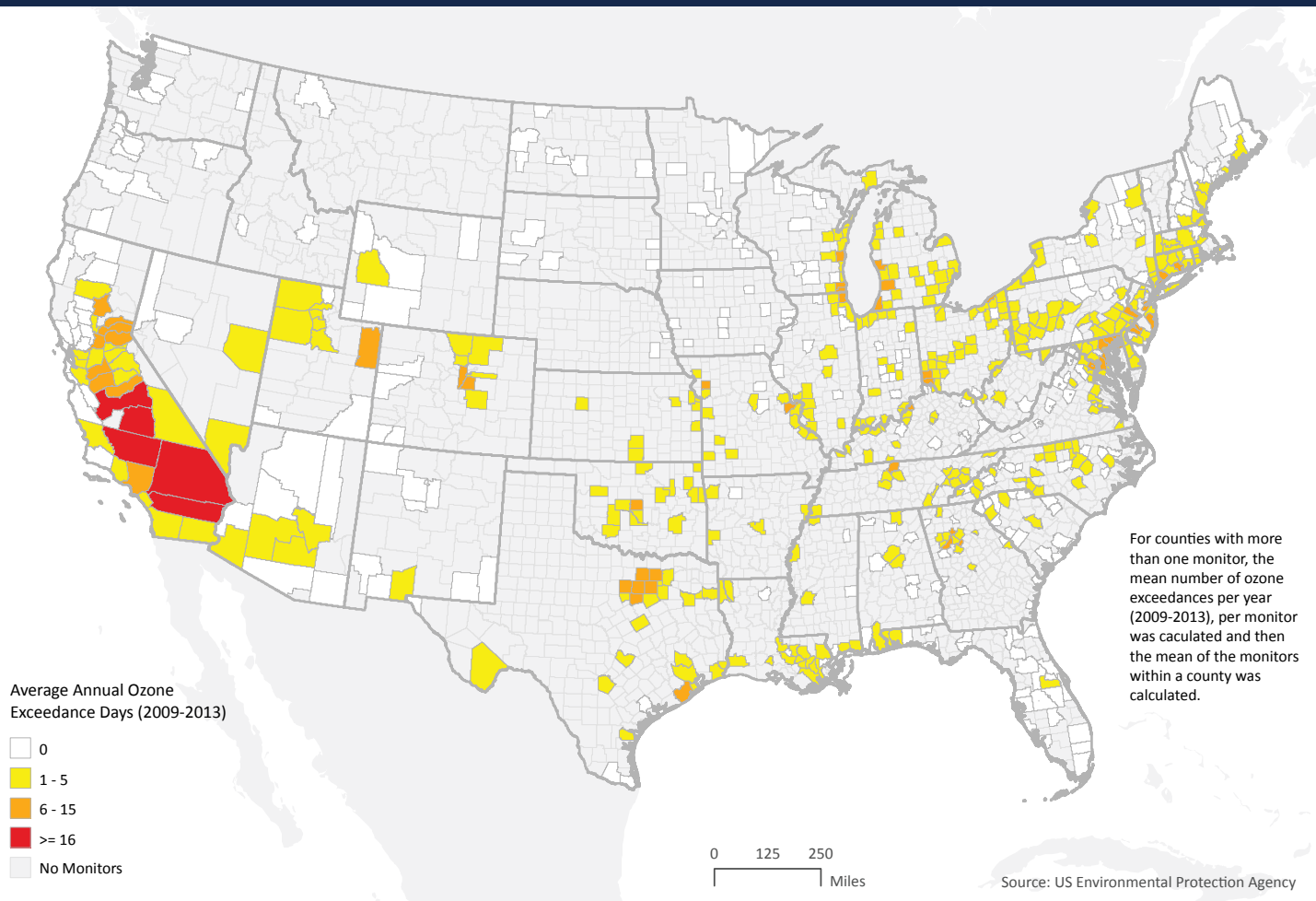


## Chicago: High rates of asthma-related deaths and ER visits

Chicago currently ranks as the ninth-worst city for asthmatics, according to the AAFA's Asthma Capitals report.<sup>69</sup> The top spots each year are reserved for the metro areas with the greatest concentration of negative factors that can potentially affect asthma patients. Contributing to Chicago's ranking as an especially challenging place for people with asthma in 2014 were relatively high death rates for asthma, asthma-related emergency room visits, and bad air quality related to ozone and PM<sub>2.5</sub> (particulate matter no more than 2.5 micrometers in diameter).

Cook County, where the Windy City is located, received an F grade for ozone smog-related air quality in the latest American Lung Association State of the Air report.<sup>70</sup> In 2014, the Chicago–Naperville metropolitan area (including Cook and surrounding counties) ranked 20th out of 277 metro areas for high-ozone days. Many people in Cook County are at risk from ozone-related health threats: In 2012, an estimated 340,025 adults—6.5 percent of the population—were diagnosed with asthma, while 231,210 (4.4 percent) suffered from chronic obstructive pulmonary disease (COPD).<sup>71</sup> In addition, 12.4 percent of the population is 65 or older, and nearly 18 percent lives in poverty, two populations that are more vulnerable to health threats due to compromised physiology and reduced means to obtain health care services.

Figure 3. Mean Number of Eight-Hour Ozone Exceedance Days per Year, 2009–2013

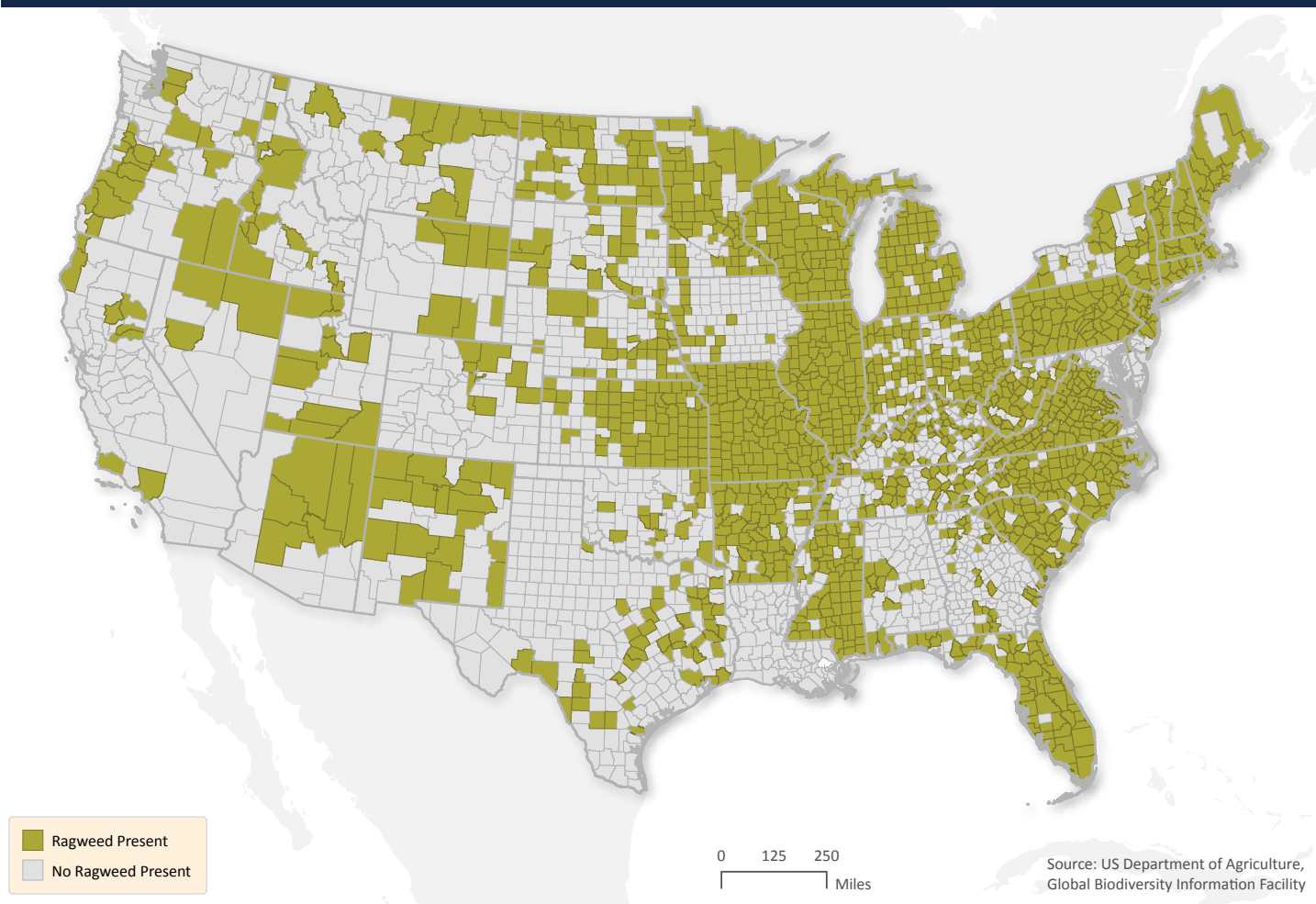


### Philadelphia: Large exposed and sensitive population

Philadelphia ranked as the fifth-worst city for asthma sufferers in 2014, according to the Asthma and Allergy Foundation of America's Asthma Capitals report.<sup>72</sup> The top spots each year are reserved for the metro areas with the greatest concentration of negative factors that can potentially affect asthma patients. Philadelphia scores worse than the current U.S. average on asthma rates and on asthma prevalence. Air quality is also worse than average, and one-quarter of the population is economically disadvantaged. Also, the latest State of the Air report by the American Lung Association gave the City of Brotherly Love an F grade for bad air quality related to ozone smog.<sup>73</sup> Philadelphia County, where the city is located, ranked 16th out of 277 metro areas for high-ozone days.

As Figure 4 shows, ragweed is found in many areas of the country. In particular, it is widely reported in the East and Midwest as well as in smaller areas of the desert Southwest and West. Some states in the Mississippi Valley, the Northeast, and the mid-Atlantic region have nearly continuous coverage of reported ragweed. This is no surprise given the highly adaptable nature of this weed species. In fact, it is likely that more counties than those shown in Figure 4 may have ragweed but have not yet reported it to agencies like the U.S. Department of Agriculture (USDA). We estimate that 100 million people currently live in areas with ragweed pollen, and levels are likely to worsen under climate change driven by increased carbon emissions.

Figure 4. Ragweed Occurrence by County (reported as of 2014)



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# RECOMMENDATIONS

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Protecting public health from respiratory ailments and other harms associated with high ozone pollution and allergen levels requires a multilevel response focused on making the air we breathe as clean as possible, and collecting more data on pollutants and allergens that contribute to or worsen health problems. In particular, given the evidence that these health threats intensify as temperatures increase, we need to take action immediately to curb the carbon pollution that is driving climate change.

In particular:

1. The U.S. Environmental Protection Agency should strengthen and finalize standards to limit carbon pollution from power plants, the largest source of carbon pollution.
2. The EPA should lower the allowable standard for ozone in air to a level that will adequately protect public health, including vulnerable groups like children, the elderly, and people suffering from asthma.
3. The U.S. government should improve the extent and frequency of ozone and ragweed pollen data collection. This could be accomplished through the following actions:
  - The U.S. Department of Agriculture (USDA), National Institutes of Health (NIH), and National Science Foundation (NSF) should collaborate to establish a comprehensive reporting and tracking system for ragweed and other potentially harmful weed species.
  - Government agencies should establish a network of daily pollen collection sites and share the information with local health practitioners and researchers, in order to inform allergy and asthma sufferers about environmental conditions that could adversely affect their health.
  - The EPA should locate more ozone monitoring stations in many areas of the country where none now exist in order to track local ozone conditions that can contribute to health-harming smog.
4. Updated and timely data on airborne pollen concentrations should be made publicly available to the scientific community and the public through the recently launched Climate Data Initiative, part of the President's Climate Action Plan.

## PROTECTING YOUR FAMILY FROM POLLEN AND OZONE

Follow these tips to avoid overexposure to ragweed pollen and ozone smog during summer and fall days with high pollen counts or high ozone concentrations, especially if you or family members have allergies or asthma.<sup>74</sup>

- Keep track of pollen counts in your area by following newspaper, radio, or television reports or checking online at [www.airnow.org](http://www.airnow.org) and [www.aaaai.org/nab](http://www.aaaai.org/nab).
- On especially high pollen or ozone days during allergy season, put car and home air conditioners on recirculate, and keep doors and windows closed.
- After working or playing outdoors, take a shower and wash your hair (or towel off with a damp cloth) to remove pollen, and change your clothes.
- Wash bedding frequently to remove pollen that settles on pillows and sheets, and vacuum regularly, preferably with a vacuum cleaner that contains a high-efficiency particulate (HEPA) filter.
- Minimize your family's exposure to other known allergens; multiple allergens can have a cumulative effect in producing symptoms.
- Try to save your most strenuous outdoor activities for days with relatively low ozone smog levels, or do them in the morning, when both ozone levels and pollen counts are lower. Check online resources like [www.airnow.gov](http://www.airnow.gov) for forecasts of local ozone conditions.
- If you have allergies or asthma, see a medical professional. Take appropriate medication and precautions; consider wearing a filter mask before doing outdoor chores.
- If you or someone in your family has received an asthma diagnosis, be sure to follow the treatment plan you and your physician have designed.
- Ask your physician to suggest other strategies for minimizing ozone and pollen exposure.

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## APPENDIX A: METHODOLOGY USED IN MAPPING RAGWEED AND OZONE

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To map ozone and ragweed conditions in the continental United States, we first surveyed current publicly available data sources. Our goal was to create maps for the entire continental United States, showing locations where residents are exposed to unhealthy levels of ozone, where ragweed is known to occur, and where people may be exposed to both ragweed pollen and ozone.

### Ozone Data and Maps

All ozone maps were derived from publicly available data from the U.S. Environmental Protection Agency website ([aq.sdr1.epa.gov/aqswb/aqstmp/airdata/download\\_files.html](http://aq.sdr1.epa.gov/aqswb/aqstmp/airdata/download_files.html)). We collected annual data for ozone for 2009–2013 and used a pre-calculated field in the EPA data that represents the number of days in the year when an eight-hour average concentration exceeded the level of the 2008 eight-hour standard (0.075 ppm). We calculated an average number of ozone exceedance days per year for only those monitors with at least 75 percent data completeness and those with data for all five years. Multiple monitors at a single site were averaged. Our method includes the total area of a county as exceeding the eight-hour ozone standard if monitors

within the county register exceedances. This can potentially overstate ozone concentrations, especially in large counties in the U.S. West, and does not take into account potential bias due to differences in urban versus rural land use/land cover in the areas surrounding the monitors. Solving this potential spatial mismatch requires dispersion modeling that considers photochemical interactions among volatile organic compounds (VOCs) and other ozone precursors, as well as local synoptic meteorology, regional transport, and topography, and is beyond the scope of the present report.

### Ragweed Data

Counties with a confirmed presence of ragweed (Figure 4) were identified using data from the USDA Natural Resources Conservation Service PLANTS database reported as of 2014 ([plants.usda.gov/index.html](http://plants.usda.gov/index.html)).<sup>75</sup> If ragweed was reported in a particular county in this database, that county was assigned to the “ragweed present” category. Although ragweed pollen has been demonstrated to travel over long distances, we did not consider long-range transport in this report.<sup>76</sup>





## APPENDIX B: SNEEZIEST AND WHEEZIEST CITIES 2014

We have compiled a list of the top Asthma Capitals that are also in ragweed-positive and eight-hour ozone exceedance—positive areas in the continental United States. Thirty-four out of the top 50 that meet these criteria, plus Richmond, Virginia, are displayed in Table B1 below:

<b>City or Metro Area</b>	<b>County</b>	<b>State</b>	<b>Population (2010)</b>	<b>Mean number of exceedances of 2008 8-hour standard (2009–2013)</b>	<b>Asthma Capital Rank</b>
Richmond	Richmond City	Virginia	204,215	n/a	1
Memphis	Shelby	Tennessee	927,644	4.3	2
Oklahoma City	Oklahoma	Oklahoma	718,633	6.7	4
Philadelphia	Philadelphia	Pennsylvania	1,526,006	5.5	5
Chattanooga	Hamilton	Tennessee	336,463	2.3	6
Chicago	Cook	Illinois	5,194,675	2.6	9
Detroit	Wayne	Michigan	1,820,584	4.5	10
New Haven	New Haven	Connecticut	862,477	4.6	11
Allentown	Lehigh	Pennsylvania	349,497	4.2	12
Atlanta	Fulton	Georgia	920,581	8.2	13
Pittsburgh	Allegheny	Pennsylvania	1,223,348	4.9	15
Louisville	Jefferson	Kentucky	741,096	4.0	16
Springfield	Hampden	Massachusetts	463,490	2.2	18
Milwaukee	Milwaukee	Wisconsin	947,735	3.6	19
Dayton	Montgomery	Ohio	535,153	5.4	21
Cleveland	Cuyahoga	Ohio	1,280,122	3.9	23
Toledo	Lucas	Ohio	441,815	1.9	25
Little Rock	Pulaski	Arkansas	382,748	2.7	27
Bridgeport	Fairfield	Connecticut	916,829	7.9	28
Akron	Summit	Ohio	541,781	2.2	31
Indianapolis	Marion	Indiana	903,393	1.8	32
Providence	Providence	Rhode Island	626,667	4.0	33
Cincinnati	Hamilton	Ohio	802,374	6.5	34
Wichita	Sedgwick	Kansas	498,365	3.7	35
Harrisburg	Dauphin	Pennsylvania	268,100	2.6	37
Nashville	Davidson	Tennessee	626,681	1.4	38
Hartford	Hartford	Connecticut	894,014	3.6	39
Phoenix	Maricopa	Arizona	3,817,117	2.6	40
Knoxville	Knox	Tennessee	432,226	1.8	41
Jackson	Hinds	Mississippi	245,285	1.0	42
Dallas	Dallas	Texas	2,368,139	7.6	43
Los Angeles	Los Angeles	California	9,818,605	15.6	44
Youngstown	Mahoning	Ohio	238,823	1.8	45
Columbus	Franklin	Ohio	1,163,414	3.0	46
Orlando	Orange	Florida	1,145,956	1.3	49

## ENDNOTES

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