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ISSUE BRIEF

CLIMATE CHANGE AND HEALTH IN VIRGINIA

Have you noticed that Virginia summers have gotten hotter and stickier? Does it seem like allergy season is more intense? Is your home flooding more often than it used to?

It's not your imagination. Climate change is altering seasonal patterns, making our summers hotter, and fueling increased flooding from coastal storms, like Hurricane Sandy in 2012.[1] As a result, we face more heat-related illnesses, air quality issues, food and water contamination, traumatic injuries, threats to our mental health, and infectious diseases.[2] These threats will only get worse as big polluters continue to pump carbon from coal, oil, and natural gas into the air.

The good news is that we can protect ourselves from these impacts by moving to cleaner energy strategies and preparing more effectively for future disasters.[3]

EXTREME HEAT IS BAD FOR VIRGINIANS' HEALTH—AND COULD BECOME MORE DEADLY

Virginia summers are getting hotter—and could become downright dangerous in just a few decades. One way to define extreme heat is to look at maximum temperatures, which have climbed about 1 degree Fahrenheit in Virginia since 1895.[4] The average national risk of death increases about 2.5 percent for every 1°F increase in the intensity of heat waves, according to one study of 43 American cities from 1987 to 2005.[5]

Daily summer highs at Richmond International Airport averaged 88.6°F in the past decade, compared with 85.6°F in the 1960s.[6] From 2007 to 2016, 36 percent of Virginians lived in counties that experienced more than nine extreme heat days per year, more days than expected on the basis of local historical averages (Figure 1).[7]

Heat and humidity already pose a range of threats to Virginia residents, from minor illnesses like heat cramps to deadly conditions like heatstroke or heat-related heart attacks.[8] In the summer of 2017, Virginia's emergency departments and urgent care clinics recorded 498 visits for heat-related issues over 10 days.[9]

The risk of heat-related illnesses and deaths in Virginia will grow as climate change fuels more intense and frequent heat waves.[10] For example, from 1975 to 2010, the Virginia Beach metropolitan area experienced an average of approximately 20 excess deaths per year on dangerously hot summer days.[11] ("Excess deaths" are the number of deaths above the daily standardized summertime average for a given area.) Without action to dramatically cut global carbon emissions from current levels, this could increase to an annual average of 170 excess deaths on dangerously hot days by the 2040s.

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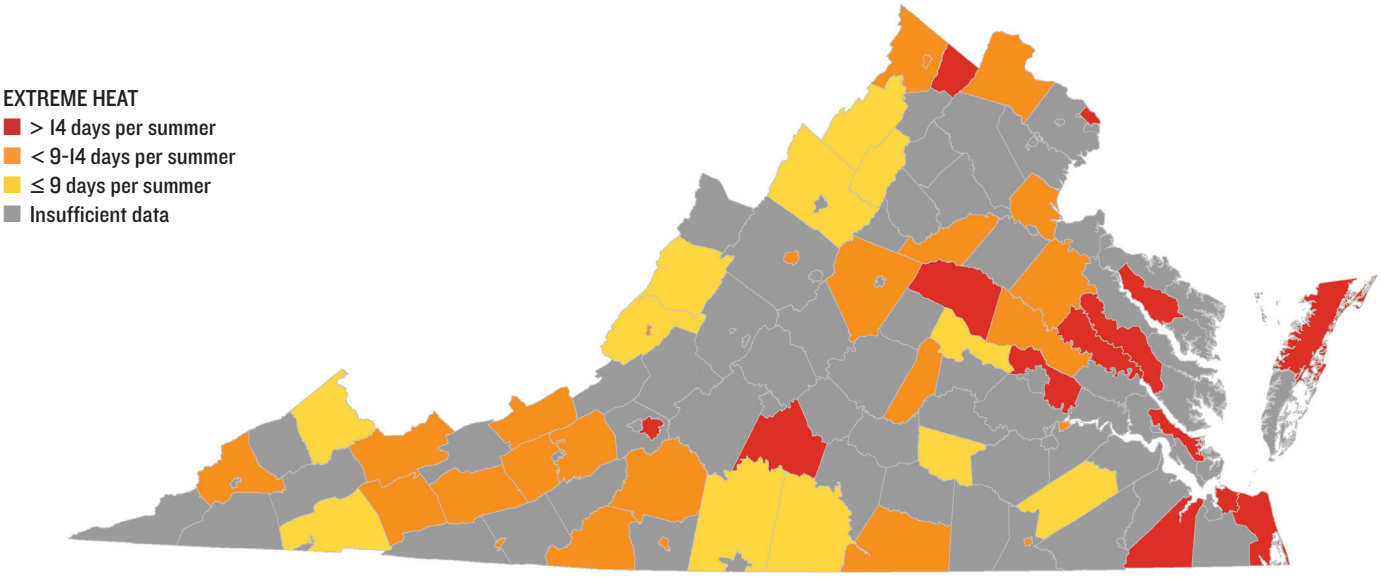
FIGURE I. AVERAGE NUMBER OF EXTREME SUMMER HEAT DAYS PER YEAR IN VIRGINIA, BY COUNTY, 2007 TO 2016

"Extreme heat days" are defined as June, July, and August days from 2007 to 2016 on which the maximum temperature at a given weather station exceeded the local 90th-percentile value for that station. We used June, July, and August days from 1961 to 1990 to calculate the 90th percentile for each station.



Source: NRDC.[12]

Anyone can get sick from extreme heat, but outdoor workers, young children, older adults, people with chronic diseases like diabetes, and people experiencing poverty are particularly vulnerable.[13] This is especially pronounced in cities, where climate warming driven by carbon pollution is amplified by tall buildings that block airflow and by heat-absorbing surfaces like asphalt.[14] In Richmond, for instance, daily summer temperatures from 2004 to 2013 were 3.1°F higher, on average, than in nearby rural areas.[15]

Heat-related illnesses impact low-income households, many of which are concentrated in city neighborhoods that have a high density of buildings and parking lots and are devoid of shade and vegetation.[16] These households may lack access to official cooling centers or be unable to afford life-saving air-conditioning.[17] More than 22 percent of the children in Virginia's 20 most urban counties experience poverty, compared with 15 percent in the state overall.[18]

COASTAL FLOODS ARE GETTING WORSE—AND COULD DISRUPT EMERGENCY HEALTH SERVICES

Coastal Virginia is experiencing one of the more challenging symptoms of a warming climate: sea level rise. The Sewells Point tide gauge in Norfolk has experienced the equivalent of 18.2 inches of relative sea level rise in the past 100 years, compared with the global average of 7 to 8 inches since 1890.[19] Because of global sea level rise and local land sinking, the low-lying Hampton Roads region in the southeast part of the state is experiencing an increase in minor tidal floods (also called "nuisance" or "sunny day" floods) that can block roads and damage homes.[20] Norfolk had 11 minor flood days in 2016, compared with 4 minor flood days in 1995.[21] In 2015, nearly half of Portsmouth residents reported they were unable to get in and out of their neighborhoods on at least one occasion that year because of repeated sunny day flooding.[22] And more than 60 percent of Hampton Roads residents worry that the effects of sea level rise already put their health at risk.[23]

The combination of sea level rise and coastal storms can make evacuation dangerous or impossible and disrupt emergency health services like ambulances, potentially delaying care and leading to loss of life.[24] Southern Virginia Beach has a dearth of potential evacuation routes, and

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hospitals and emergency shelters are already difficult to access.[25] By 2080, 4 feet of relative sea level rise could flood about 10 percent of the interstate highways and arterial and primary roads in Virginia Beach and Norfolk during exceptionally high tides known as "king tides."[26] If a 100-year storm surge (floods with a 1 percent chance of occurring in a given year) coincided with a king tide, flooding could cover more than 50 percent of roadways in the same area. Note that more than one 100-year flood can occur in a given century.[27]

Flood-related damage or blocked roadways aren't good for anyone but can be especially difficult for those with low incomes, who may have trouble paying for rent, food, or doctors' bills if they can't get to work.[28] Parts of Norfolk and Portsmouth have some of the highest poverty rates in the state.[29] Furthermore, 52 percent of area renters spend more than 30 percent of their household income on rent—a marker of housing instability.[30]

CLIMATE CHANGE COULD CONTAMINATE VIRGINIA'S DRINKING WATER

Sea level rise will affect something many of us take for granted: safe drinking water. More than 5.5 million people lived in Virginia's coastal watershed counties in 2010, and the coastal population is expected to grow.[31] Coastal Virginians get their drinking water from a combination of surface water sources and groundwater sources that are largely below sea level.[32]

The combination of sea level rise and well pumping (which can allow saltwater under aquifers to flow upward) threatens to make coastal groundwater saltier. Excess salt concentrations in drinking water may increase blood pressure in sensitive individuals and can contribute to strokes and heart attacks.[33] Salt can also corrode water distribution pipes, which increases the likelihood of unhealthy lead or copper contamination.[34]

Increases in extreme precipitation will likely lead to more contaminated runoff in water and more failures of drinking water systems and wastewater treatment facilities across the country.[35] Nearly 70 percent of waterborne disease outbreaks in the United States between 1948 and 1994 were preceded by heavy precipitation.[36] In the Southeast, the amount of rain falling in the heaviest one-day storms increased 27 percent from 1958 to 2016.[37] In Virginia, the number of days with more than 2 inches of precipitation increased from 1995 to 2014, and that trend is expected to continue as the climate warms.[38] This poses a problem for cities, like Richmond, that have combined sewer overflow systems.[39] During heavy rains, these combined systems dump untreated sewage and other contaminants into rivers, lakes, and coastal waters. Combined sewer overflows were a major source of *Escherichia coli*—an indicator of fecal contamination—in Richmond's James River Basin in 2012.[40]

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RISING TEMPERATURES COULD MAKE VIRGINIA'S SEAFOOD DANGEROUS TO EAT

Virginia is home to a multitude of fishable streams and lakes and more than 3,300 miles of marine coastline.[41] But rising temperatures threaten the safety of the fish and shellfish those waters provide—including oysters, the pride of coastal Virginia.[42]

Vibriosis, which is spread by bacteria-laden seawater or seafood, can cause symptoms ranging from nausea to skin infections.[43] The illness affects an estimated 80,000 people and causes about 100 deaths in the United States every year. Anyone can get vibriosis, but severe complications are more likely for people with weakened immune systems or chronic diseases like cancer or liver disease, or for those who take medications to reduce stomach acid.[44]

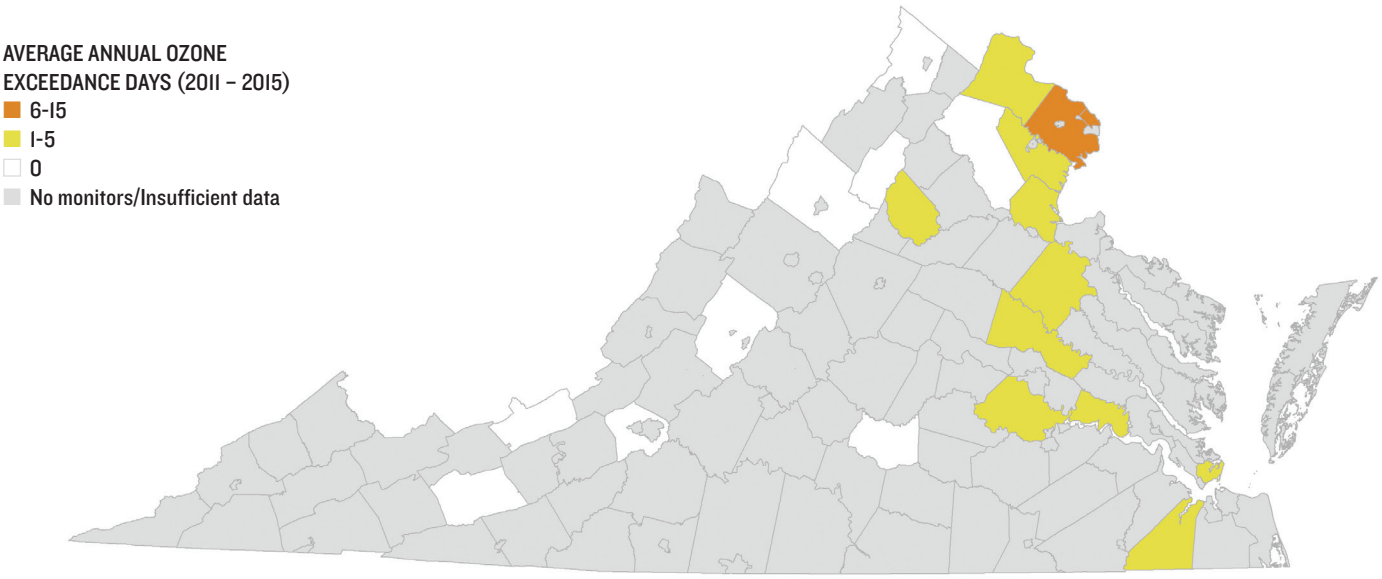
Vibrio bacteria concentrations in the temperate North Atlantic have risen over the last half century, and researchers have linked this rise to warming sea surface temperatures.[45] As the Chesapeake Bay area gets warmer, the likelihood of *Vibrio vulnificus* bacteria, which can cause symptoms like bloody diarrhea and vomiting, is expected to increase in bay water.[46] Warmer temperatures could also increase the concentration of *V. parahaemolyticus* bacteria, which can cause deadly bloodstream infections, in the area's oysters.

CLIMATE CHANGE PUTS VIRGINIA'S PROGRESS TOWARD CLEANER SKIES AT RISK

Virginia's air quality has improved since 2004 largely because of federal pollution limits.[47] However, climate change could undermine the state's progress toward cleaner air and make it harder to meet future air quality standards.[48] This is especially pertinent in the 12 Virginia counties that already experience an average of 2 to 9.7 unhealthy smog days per year (Figure 2).[49] Smog forms when pollution from power plants, vehicles, and other sources reacts with sunlight to create ground-level ozone.[50] Rising temperatures can speed up this process and lead to more smog. In the southeastern United States, warmer and drier fall weather could also extend the summer smog season into fall.[51]

FIGURE 2. VIRGINIA COUNTIES AVERAGING ONE OR MORE UNHEALTHY GROUND-LEVEL OZONE DAYS PER YEAR, 2011 TO 2015

Ozone exceedances are days when an eight-hour average concentration of ozone exceeds the EPA's 2015 Ozone National Ambient Air Quality Standard of 0.070 parts per million.



Source: NRDC.[55]

Smog and small particulate matter, another type of pollution from burning fossil fuels, are powerful triggers for asthma, threatening the health of Virginia's estimated 159,000 children and 518,000 adults with the condition.[52] These forms of air pollution have also been linked to preterm births, birth defects, developmental delays in children, strokes, heart attacks, dementia in older adults, lung cancer, and other health problems.[53] Smog and particle pollution from Virginia power plants cause an estimated 400 premature deaths per year from asthma and other causes in Virginia and nearby states.[54]

Climate-fueled increases in smog will increase health care costs for asthma, which is already an expensive disease to treat.[56] In 2012, for example, asthma generated an estimated $2,208 in medical costs per patient in Virginia and a cumulative cost of $76.7 million in lost work and school days.[57] The burden of worsening air quality will fall heavily on low-income families and children of color. For example, in the Washington-Arlington-Alexandria metropolitan area, there are nearly twice as many African-American and Hispanic households in severely or moderately inadequate housing as there are white households.[58] Children who live in poor-quality housing are 45 percent more likely to be diagnosed with asthma and 59 percent more likely to be treated in an emergency room for it.[59]

ALLERGY SEASONS ARE GETTING LONGER AND MORE SEVERE

Seasonal pollen allergies, also known as hay fever, are common across Virginia. In 2016, Richmond was the 14th most challenging city in the nation in terms of spring allergies.[60] Hay fever symptoms, such as congestion and headache, can range from mildly annoying to downright disruptive, affecting sleep, mood, and quality of life.[61]

Rising temperatures are leading to earlier spring allergy seasons across the United States.[62] The carbon dioxide driving climate change is also stimulating plant growth, boosting pollen production. From 2001 to 2010, the oak pollen season started nearly four days earlier, on average, than in the previous decade, according to a study of six monitoring sites in the southeastern United States.[63] Peak pollen counts averaged 117 percent higher in that same period. In 2017, Allergy Partners of Richmond reported its fourth-highest tree pollen count since the group began recording data outside its clinic in 1989.[64]

Asthma threats increase when there's more pollen in the air. In 2010, asthma triggered by oak pollen led to an estimated 8,800 emergency room visits in the Southeast. By the 2050s, emergency room visits for oak-related asthma attacks could increase 4 percent under continued high levels of carbon pollution.[65]

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Blacklegged ticks, which can carry the bacteria that cause Lyme disease, are expanding to new counties in Virginia at an explosive rate. In 1996, the ticks were reported or established in only 12 of Virginia's 95 counties; this had increased to 72 counties by 2016.

MOSQUITO- AND TICK-BORNE INFECTIONS ARE INCREASING

Climate change helps make it possible for ticks and mosquitoes to live in new places and be active earlier in the year.[66] That's bad news for the more than 49,260 Virginians who work in outdoor occupations such as farming, landscaping, and highway construction.[67] It also affects millions of Virginia residents who enjoy visiting natural areas, gardening, and other outdoor recreation every year.[68]

Virginia is one of 14 hot-spot states for Lyme disease, the most common tick-borne illness in the United States.[69] In its early stages, Lyme disease causes flulike symptoms. Later on—weeks or months after a bite by an infected tick—people with Lyme disease can suffer debilitating muscle and joint pain, headaches, memory problems, and even fatal heart damage.[70] In Virginia, there were 10,761 confirmed or probable cases of Lyme disease reported between 2008 and 2015.[71]

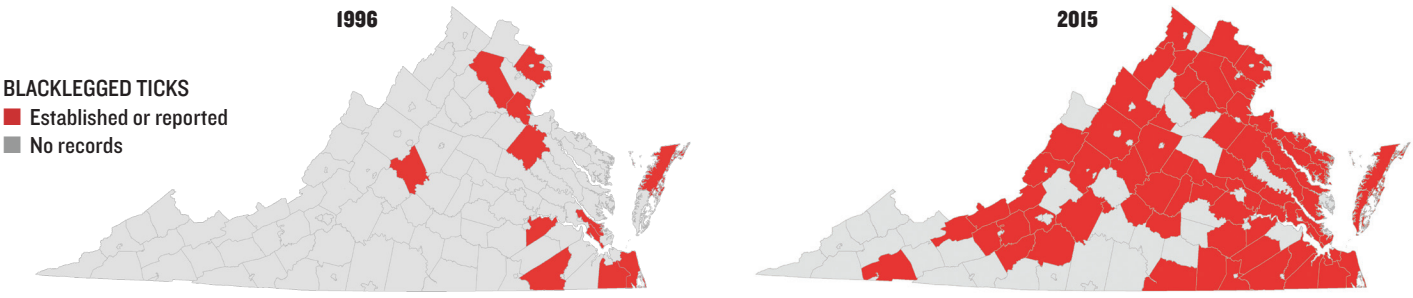
Blacklegged ticks, which can carry the bacteria that cause Lyme disease, are expanding to new counties in Virginia at an explosive rate. In 1996, the ticks were reported or established in only 12 of Virginia's 95 counties; this had increased to 72 counties by 2016 (Figure 3).[72] Lyme disease cases are also spreading to new areas of the state, potentially due to a combination of climate change, habitat change, and local increases in the population of deer and mice that carry ticks.[73] In addition, warmer springs will likely encourage an earlier start to Lyme disease season. By the 2060s, the season could begin three weeks earlier in Virginia than it did from 1992 to 2007.[74]

West Nile virus was first reported in Virginia in 2002, and a total of 163 cases have been reported in the state since then.[75] The disease, which is typically spread by mosquitoes, causes symptoms like vomiting and fatigue in about 1 in 5 people who are infected.[76] More rarely, infected patients develop severe neurological illnesses that can be fatal. Extremely hot and dry years projected from 2036 to 2049 could increase the average annual number of neuroinvasive West Nile cases more than 20-fold (compared to 1999 to 2013).[77]

Rising temperatures and humidity are also extending the mosquito season in Virginia cities, increasing the possibility of transmission of Zika, dengue, and other viruses.[78] In the state's largest cities, there was an average of 131 suitable days each year for Asian tiger mosquito activity from 2006 to 2015, compared with 113 such days annually from 1980 to 1989.[79]

FIGURE 3. DISTRIBUTION OF BLACKLEGGED TICKS IN VIRGINIA, 1996 AND 2015

Counties in Virginia where blacklegged ticks were reported (fewer than six ticks of a single life stage) or established (six or more ticks or two tick life stages) in 1996 and 2015.



Source: Modified from Eisen et al., *Journal of Medical Entomology* 53 (2016).

ACTING ON CLIMATE CAN PROTECT OUR HEALTH

The good news is that cleaning up power plants, vehicles, and other big sources of pollution will help protect our health by limiting the dangerous effects of climate change and by cutting unhealthy smog, particulate matter, and other air pollution.

Virginia has already made progress to address climate change, reducing total carbon dioxide emissions by more than 20 percent from 2005 to 2015.[80] Those efforts have also helped clean up the air Virginians breathe. For example, Arlington County's efforts to make traffic flow more efficiently and to enhance public transportation, cycling, and walking avoided the emission of more than 511,000 tons of carbon dioxide (equivalent to the emissions from more than 1.1 billion passenger vehicle miles) from 2008 to 2014. These efforts also eliminated more than 950,000 pounds of nitrogen oxides, a building block of smog and particle pollution, in the same period.[81] And from 2007 to 2017, Virginia's wind and solar power plants averted the emission of more than 1.6 million metric tons of carbon dioxide, more than 4,000 metric tons of sulfur dioxide, and more than 2,000 metric tons of nitrogen oxides.[82]

In March 2018, the Virginia state legislature passed a bill that mandates the investment of more than $1 billion in energy efficiency (including programs targeting low-income households), solar and wind energy, and electric grid modernization.[83] But there's a lot more to do. For instance, the state took a big step forward in November 2017 by approving a proposal to cut carbon pollution by 30 percent between 2020 and 2030.[84] As part of that plan, Virginia intends to join the Regional Greenhouse Gas Initiative (RGGI), a multistate program to limit carbon pollution from power plants. The air pollution reduced through the program from 2009 to 2014 generated an estimated $5.7 billion in health benefits in RGGI states and neighboring states—including Virginia.[85] Over that period, RGGI helped Virginia residents avoid a total of up to 53 premature adult deaths, an estimated 761 asthma attacks, and about 3,621 missed work days.[86] If Virginia joins RGGI, it will further boost air quality benefits to RGGI states and to their neighbors.

The health benefits of cutting carbon pollution aren't limited to reducing climate-related threats and improving air quality. Transportation is Virginia's largest source of carbon dioxide pollution.[87] A smarter and cleaner transportation system (for example, one that incentivizes more efficient vehicles and alternatives to cars) could help limit emissions and reduce the stress associated with traffic jams, improve access to health care among those who can't drive or don't own a car, and reduce premature mortality thanks to increased physical activity.[88]

Virginia also needs to create and implement more detailed plans to address the health impacts of climate change that are already being felt today. The state's 2008 climate action plan recommended several health initiatives—including tracking temperature-driven increases in the incidence of allergic diseases—but there has been little progress since then.[89] As of March 2018, the Virginia Department of Health website did not even mention climate change. In the near term, the Department of Health should develop a climate vulnerability assessment that combines data on socioeconomic and other health-risk factors with information about the ability of communities, health providers, and other key institutions to cope with the health consequences of climate threats. Such an assessment would help the state make evidence-based choices about which climate impacts to prioritize and how best to help the people most vulnerable to those impacts.[90]

The bottom line is that Virginia residents have much to gain from climate action—and lives to lose if we fail to clean up climate-changing pollution and build resilience to the shifts that have already occurred.

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