MassEnviroScreen Technical Documentation

Executive Office of Energy and Environmental Affairs

Office of Environmental Justice and Equity

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Introduction

This document describes MassEnviroScreen, a GIS-based mapping tool designed to identify communities facing the greatest environmental burdens and levels of social vulnerability in Massachusetts. MassEnviroScreen integrates 30 statewide indicators into a cumulative burden score that incorporates exposure to pollution and climate risks and the intersection of these risks with conditions of vulnerability – the health and socioeconomic characteristics of communities. This tool was developed to support consistent, data-informed approaches to understanding cumulative environmental and social burdens across the Commonwealth of Massachusetts.

Measuring Cumulative Burdens and Impacts

Cumulative burdens or impacts (used interchangeably here) are commonly defined as the "the totality of exposures to combinations of chemical and non-chemical stressors and their effects on health, well-being, and quality of life outcomes."[1] The term "stressors" in this definition refers to a physical, chemical, biological, or other effect that can cause an adverse response in a human, other organism, or ecosystem (including socioeconomic status, existing exposures, existing health outcomes, etc.).[2] Cumulative impact measurement refers to "the systematic practice of quantifying the combined effect on environmental and social systems from multiple, successive, or concurrent human activities over a defined time period and geographical area."[3] Cumulative impact measurement and assessment have been adopted by community advocates, researchers, environmental health regulators, and public policy makers as a more holistic approach to acknowledging, understanding, and addressing the complex intersection of environmental and social conditions that affect a community or population, especially marginalized and overburdened communities.

Cumulative impact measurement stands in contrast to the conventional approach of environmental policy. Conventional environmental policy considers individual environmental risks one-at-a-time, in one medium at a time (i.e., air, water, land), or in isolation from the context of environmental and social conditions that are already present in a community. Moreover, conventional environmental policy does not consider

[1] US EPA, *Cumulative Impacts Research: Recommendations for EPA's Office of Research and Development*, Reports and Assessments EPA/600/R-22/014a, 2022 (U.S. Environmental Protection Agency, 2022), https://www.epa.gov/healthresearch/cumulative-impacts-research.

[2] Kristie M. Ellickson et al., "Cumulative Risk Assessment and Environmental Equity in Air Permitting: Interpretation, Methods, Community Participation and Implementation of a Unique Statute," *International Journal of Environmental Research and Public Health* 8, no. 11 (2011): 11, https://doi.org/10.3390/ijerph8114140.

[3] "Cumulative Impact Measurement," ESG Sustainability Directory, accessed April 11, 2026, https://esg.sustainability-directory.com/area/cumulative-impact-measurement/.

the unequal exposure or sensitivity of different populations.[4] Cumulative impact measurement also differs from conventional approaches by integrating both physical environmental conditions (e.g., air quality, water quality, flood risk) and social conditions (e.g., health, wealth, labor participation, education, or age).[5] Finally, cumulative impact measurement is not the same as cumulative risk measurement or assessment. While the primary purpose of the latter is to inform understanding of well-defined adverse environmental health outcomes, cumulative impact measurement characterizes broader community conditions by incorporating quantitative and qualitative data on burdens and benefits which may not strictly be classified as environmental health stressors or outcomes.[6] Moreover, policies incorporating cumulative impact measurement are grounded not just in a concern for physical health outcomes, but also in concerns about environmental justice and social equity.

State of the Science on Cumulative Impact Measurement

Environmental burdens do not exist in isolation from the broader environmental and social context in which they occur. Since the early 1980s, researchers have repeatedly documented the unequal distribution of burdens or risks. There is significant empirical evidence that the distribution of environmental burdens assets are spatially clustered, and strongly and consistently associated with community demographics – race/ethnicity, wealth, education, English language fluency, and housing tenure (i.e., owners versus renters).[7] These patterns are significant because they show that some communities are more likely to be exposed to, or burdened with, unequal concentrations of multiple

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[4] Thomas A. Burke et al., "Rethinking Environmental Protection: Meeting the Challenges of a Changing World," *Environmental Health Perspectives* 125, no. 3 (2017): A43–49, https://doi.org/10.1289/EHP1465; *Transforming EPA Science to Meet Today's and Tomorrow's Challenges*, with Committee on Anticipatory Research for EPA's Research and Development Enterprise to Inform Future Environmental Protection: The Road Ahead et al. (National Academies Press, 2023), https://doi.org/10.17226/26602.

[5] *State of the Science and the Future of Cumulative Impact Assessment: Proceedings of a Workshop–in Brief*, with Board on Environmental Change and Society et al. (National Academies Press, 2025), https://doi.org/10.17226/29058.

[6] N. Tulve et al., "Similarities and Differences between Cumulative Impact Assessment and Cumulative Risk Assessment," Reports and Assessments, SRA 2024 annual meeting, December 2024, https://assessments.epa.gov/risk/document/&deid%3D364704.

[7] Robert D. Bullard et al., *Toxic Wastes and Race at Twenty 1987—2007: A Report Prepared for the United Church of Christ Justice & Witness Ministries* (United Church of Christ Justice & Witness Ministries, 2007), https://www.ucc.org/what-we-do/justice-local-church-ministries/justice/faithful-action-ministries/environmental-justice/environmental-ministries_toxic-waste-20/; Rachel Morello-Frosch and Russ Lopez, "The Riskscape and the Color Line: Examining the Role of Segregation in Environmental Health Disparities," *Environmental Research*, IG000012, vol. 102, no. 2 (2006): 181–96, https://doi.org/10.1016/j.envres.2006.05.007; Rachel Morello-Frosch et al., "Understanding the Cumulative Impacts of Inequalities in Environmental Health: Implications for Policy," *Health Affairs (Project Hope)* 30, no. 5 (2011): 879–87, https://doi.org/10.1377/hlthaff.2011.0153; Jayajit Chakraborty and Juliana A. Maantay, "Proximity Analysis for Exposure Assessment in Environmental Health Justice Research," in *Geospatial Analysis of Environmental Health* (Springer, Dordrecht, 2011), https://doi.org/10.1007/978-94-007-0329-2_5.

overlapping or intersecting stressors that must be considered holistically to understand the significance of introducing additional burdens. This inequality of exposure also raises significant concerns about environmental health and environmental justice.

Environmental exposures are linked to a variety of adverse health outcomes.[8] There is also significant research demonstrating that sensitivity or vulnerability to environmental stressors varies due to intrinsic and extrinsic factors.[9] Two individuals with identical exposure to the same stressor may experience very different outcomes due to biological or physiological differences and due to social or structural factors. The reality is that communities vary in both their level of exposure to various environmental stressors and in their sensitivity or vulnerability to those stressors. Problematically, it is often the most vulnerable communities that also experience the greatest exposure.

The social determinants of health paradigm highlights the complex and critical relationship between extrinsic factors - social conditions or structures - and human health. Health disparities between population groups or communities are reflective of differing social conditions related to economic stability, educational access and quality, health care access and quality, conditions of the neighborhood and built environment, and social and community context.[10] However, the causal connections are not simple or unidirectional. For example, poverty is associated with a range of adverse health conditions. Conversely, adverse health conditions can lead to impoverishment.[11] Social and structural conditions (e.g., discrimination, residential segregation, generational wealth, geography) influence individual and community access to a range of core life resources – wealth, housing, food, medical care – and mediate exposure to a range of environmental stressors – air and water pollution, lead, toxics in the school or workplace, and violence. Half of all the variation in health outcomes are traced to these

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[8] Zinzi D. Bailey et al., "Structural Racism and Health Inequities in the USA: Evidence and Interventions," *The Lancet* 389, no. 10077 (2017): 1453–63, https://doi.org/10.1016/S0140-6736(17)30569-X; Morello-Frosch et al., "Understanding the Cumulative Impacts of Inequalities in Environmental Health"; US EPA, *Environmental Justice Research Roadmap*, EPA 601/R-16/006 (2016), https://www.epa.gov/sites/default/files/2017-01/documents/researchroadmap_environmentaljustice_508_compliant.pdf.

[9] James R. Elliott and Jeremy Pais, "Race, Class, and Hurricane Katrina: Social Differences in Human Responses to Disaster," *Social Science Research*, Katrina in New Orleans/Special Issue on Contemporary Research on the Family, vol. 35, no. 2 (2006): 295–321, https://doi.org/10.1016/j.ssresearch.2006.02.003; Christian Henrik Alexander Kuran et al., "Vulnerability and Vulnerable Groups from an Intersectionality Perspective," *International Journal of Disaster Risk Reduction* 50 (November 2020): 101826, https://doi.org/10.1016/j.ijdrr.2020.101826; Stacia S. Ryder, "A Bridge to Challenging Environmental Inequality: Intersectionality, Environmental Justice, and Disaster Vulnerability," *Social Thought & Research* 34 (2017): 85–115.

[10] "Social Determinants of Health - Healthy People 2030 | Odphp.Health.Gov," accessed June 2, 2025, https://odphp.health.gov/healthypeople/priority-areas/social-determinants-health.

[11] "Health and Wealth: Why Americans Are Drowning in Medical Debt," *Marketplace*, directed by Wealthby David Brancaccio et al., NPR, March 27, 2024, https://www.marketplace.org/story/2024/03/27/health-and-wealth-why-americans-are-drowning-in-medical-debt.

social determinants of health, and these social determinants are a major driver of health. [12]

The current scientific understanding of cumulative impacts is supported by four key concepts:[13]

- There are significant health disparities among marginalized groups (i.e., racial/ethnic minorities, lower income people, etc.) that are linked to social and environmental factors;
- Unequal exposure to environmental hazards are significant and linked to increased risk of adverse outcomes;
- Intrinsic biological or physiological factors, such as age, chronic disease, and life stage can amplify the effects of environmental stressors and contribute to health disparities;
- Extrinsic social and structural factors for individuals and communities, such as racial/ethnic discrimination, residential or occupational segregation, and socioeconomic status, can amplify the effects of environmental stressors and contribute to health disparities

The aggregate and interacting effects of chemical and non-chemical stressors has gained increasing attention as a critical focus of science and policy. A report by the National Academies of Sciences, Engineering, and Medicine ("NASEM") goes so far as to assert that "most adverse human health and ecosystem impacts are the result of the cumulative effects of multiple interactive environmental and social stressors."[14]

While the science of cumulative exposures to environmental stressors is still evolving,[15] there has been significant advancement in recent years on cumulative impact

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[12] DHHS, *HHS's Strategic Approach to Addressing Social Determinants of Health to Advance Health Equity – At a Glance* (U.S. Department of Health and Human Services, 2022), https://aspe.hhs.gov/sites/default/files/documents/aabf48cbd391be21e5186eeae72.

[13] Gina M. Solomon et al., "Cumulative Environmental Impacts: Science and Policy to Protect Communities," *Annual Review of Public Health* 37, no. Volume 37, 2016 (2016): 83–96, https://doi.org/10.1146/annurev-publhealth-032315-021807; *Transforming EPA Science to Meet Today's and Tomorrow's Challenges*.

[14] *Transforming EPA Science to Meet Today's and Tomorrow's Challenges*.

[15] *Transforming EPA Science to Meet Today's and Tomorrow's Challenges*; US EPA, *Cumulative Impacts Research: Recommendations for EPA's Office of Research and Development*, EPA/600/R-22/014a, 2022 (US Environmental Protection Agency, 2022), https://www.epa.gov/system/files/documents/2022-09/Cumulative%20Impacts%20Research%20Final%20Report_FINAL-EPA%20600-R-22-014a.pdf; US EPA, *Interim Framework for Advancing Consideration of Cumulative Impacts* (US Environmental Protection Agency, 2024); National Academies of Sciences, Engineering, and Medicine, *Constructing Valid Geospatial Tools for Environmental Justice*, with Committee on Utilizing Advanced Environmental Health and Geospatial Data and Technologies to Inform Community Investment et al. (National Academies Press, 2024), https://doi.org/10.17226/27317.

measurement, assessment, and screening tools in both science and policy. Seminal reports by the US EPA[16] – as well as NASEM[17] – provide firmer ground for the scientific context of cumulative impact measurement and the necessity of its advancement and implementation to better understand and address environmental health and well-being. More than a dozen states and other jurisdictions have adopted cumulative impact measurement or assessment policies and screening tools to guide environmental permitting, enforcement, and the prioritization of resources in overburdened communities, providing a growing array of examples and collective learning.[18] These tools enable decision-makers to better target protections and investments to areas of greatest need, thereby helping reduce health and environmental inequities.

To provide more concrete guidance to federal, state, and other organizations, NASEM published a landmark report which surveyed the landscape of environmental screening methodologies and tools and distills important lessons on their design and implementation[19]. In part because screening tools and their methods of measuring cumulative burden through "composite indicators" can take many forms, guidance on the development of screening tools and these composite indicators prioritizes the process of development, rather than any specific set of indicators or algorithms. There is no particular formulation of a screening tool for cumulative impact measurement, including indicator choices or methods of aggregation, that is universally accepted or appropriate. Rather, best practice recommendations are that they should be developed in a way that reflects the unique purpose of the tool and which is accepted by its users.[20] NASEM developed recommendations on screening tools or composite indicator construction to support environmental justice efforts, including cumulative impact measurement. NASEM argues that "sound composite indicators are developed with a clearly defined purpose and intended audience and reflect real world conditions. The

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[16] OEJECR US EPA, "Interim Framework for Advancing Consideration of Cumulative Impacts," Data and Tools, November 13, 2024, https://www.epa.gov/cumulative-impacts/interim-framework-advancing-consideration-cumulative-impacts.

[17] National Academies of Sciences, Engineering, and Medicine, *State of the Science and the Future of Cumulative Impact Assessment* (The National Academies Press, 2025), https://doi.org/10.17226/29182.

[18] Ana Isabel Baptista et al., *Understanding The Evolution of Cumulative Impacts: Definitions And Policies In The U.S.* (Tishman Environment and Design Center at The New School, 2022), https://www.tishmancenter.org/projects-publications; Vermont Law School Environmental Justice Clinic, "Environmental Justice State by State Law Library & Database," Environmental Justice State by State | A Law Library for Community Advocates, Attorneys, Scholars, and Policymakers, accessed July 14, 2023, https://ejstatebystate.org.

[19] National Academies of Sciences, Engineering, and Medicine, *Constructing Valid Geospatial Tools for Environmental Justice* (Washington, DC: The National Academies Press, 2024), https://doi.org/10.17226/27317.

[20] OECD, *Handbook on Constructing Composite Indicators: Methodology and User Guide - OECD* (Organisation for Economic Co-operation and Development, 2008), https://www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm.

validity of a tool rests on a foundation of scientific and methodological rigor, meaningful and sustained participation and input from community and other interested and affected parties, transparency, and acceptance by institutional actors (e.g., government agencies), communities, and other affected parties."[21] MassEnviroScreen, and this documentation, represent ongoing efforts to adhere to these best practices.

Policy Context

In November 2024, the Commonwealth of Massachusetts enacted "An Act promoting a clean energy grid, advancing equity, and protecting ratepayers" (the "2024 Climate Act").[22] This landmark legislation established the Office of Environmental Justice and Equity ("OEJE") within the Executive Office of Energy and Environmental Affairs ("EEA"). The 2024 Climate Act directs OEJE to integrate environmental justice principles into the operations of EEA and its agencies and to develop guidance on cumulative impact analysis ("CIA") for use in siting and permitting decisions.

Environmental justice principles are principles that support protection from environmental pollution and the ability to live in and enjoy a clean and healthy environment, regardless of race, color, income, class, handicap, gender identity, sexual orientation, national origin, ethnicity or ancestry, religious belief or English language proficiency, which includes:

i. the meaningful involvement of all people with respect to the development, implementation and enforcement of environmental laws, regulations and policies, including climate change policies; and

ii. the equitable distribution of energy and environmental benefits and environmental burdens."[1]

Guided by the 2024 Massachusetts EEA Environmental Justice Strategy,[23] OEJE has been working collaboratively with EEA agencies to develop a framework for incorporating cumulative impacts into the evaluation of projects, programs, and policies. As part of this effort, OEJE developed the MassEnviroScreen to provide a single, publicly-accessible tool to visualize where these cumulative burdens exist.

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[21] National Academies of Sciences, Engineering, and Medicine, *Constructing Valid Geospatial Tools for Environmental Justice*.

[22] An Act Promoting a Clean Energy Grid, Advancing Equity, and Protecting Ratepayers, Pub. L. No. Chapter 239 of the Acts of 2024 (2024), https://malegislature.gov/Laws/SessionLaws/Acts/2024/Chapter239; "Governor Healey Signs Climate Law to Advance Clean Energy Transition, Create Jobs and Lower Costs | Mass.Gov," accessed May 30, 2025, https://www.mass.gov/news/governor-healey-signs-climate-law-to-advance-clean-energy-transition-create-jobs-and-lower-costs.

[23] Massachusetts Executive Office of Energy and Environmental Affairs, *Environmental Justice Strategy: Secretariat and Agency Strategies for Proactively Promoting Environmental Justice in the Commonwealth of Massachusetts* (Massachusetts Executive Office of Energy and Environmental Affairs, 2024), https://www.mass.gov/doc/february-2024-environmental-justice-strategy-english/download.

MassEnviroScreen operationalizes environmental justice principles by enhancing transparency and supporting meaningful public participation in environmental decision-making. By identifying communities experiencing disproportionate cumulative burdens, the tool informs equitable planning, resource allocation, and mitigation strategies. In doing so, MassEnviroScreen serves as a foundational mechanism for supporting CIA for siting and permitting decisions and ensuring that EEA agencies consistently incorporate environmental justice considerations into their actions.

Development and Collaboration

The development of MassEnviroScreen reflects a comprehensive and collaborative effort led by OEJE. OEJE was supported by StarLuna Consulting, LLC, whose technical expertise contributed to the development of the tool's methodology, data integration, and geospatial analysis. Guided by the mandates of the 2024 Climate Act and EEA's Environmental Justice Strategy, the tool was developed through an iterative process that incorporated interagency coordination, technical expertise, and engagement with community stakeholders. This collaborative approach allows for methodology that is scientifically robust, transparent, and responsive to the needs and experiences of communities, resulting in a consistent and credible framework for identifying areas experiencing cumulative burdens across Massachusetts.

Significant discussion of MassEnviroScreen occurred within stakeholder engagement processes established to support implementation of the 2024 Climate Act, which introduced comprehensive reforms to the siting and permitting of energy infrastructure in the Commonwealth. These reforms – led by the EEA, Energy Facilities Siting Board ("EFSB"), Department of Public Utilities ("DPU"), and Department of Energy Resources ("DOER") – included the development of new regulations requiring streamlined permitting processes, cumulative impact analysis, and enhanced community engagement as part of project review. As OEJE advanced guidance for CIA, MassEnviroScreen served as a key tool within these parallel regulatory and policy discussions, with input from community-based organizations, environmental justice advocates, academic and public health experts, industry stakeholders, and the public informing both the design of the tool and its application within the Commonwealth's evolving siting and permitting framework. Feedback gathered through public meetings, listening sessions, interagency coordination, and formal regulatory comment periods informed key aspects of the tool, including indicator selection, data transparency, usability, and accessibility.

The process and timeline for MassEnviroScreen development included the following steps:

- Beginning in Summer 2024, OEJE began review of relevant literature and survey of existing state tools for mapping cumulative burdens
- Beginning in December 2024, OEJE conducted meetings with EJ stakeholders, academic experts, public health experts, and state staff to identify priority indicators and provide feedback on cumulative burden mapping approaches
- On May 5, 2025, EEA, EFSB, DPU and DOER jointly conducted a public stakeholder session in Holyoke, MA on MassEnviroScreen, Cumulative Impacts Analysis and Site Suitability Criteria and received oral and written feedback
- On June 25, 2025, OEJE hosted a virtual public meeting on MassEnviroScreen and the Standards and Guidelines for Cumulative Impact Analysis and Community Benefits Plans.
- In July 2025, the EFSB staff issued for discussion purposes draft proposed regulations and guidance on Cumulative Impact Analysis, which included discussion on the underlying methodology and proposed use of MassEnviroScreen. The Siting Board conducted a public meeting to hear comments on the draft proposed regulations and guidance.
- In November 2025, a draft version of MassEnviroScreen GIS-mapping tool and technical documentation was released for public review and comment.
- On January 23, 2026, OEJE released a revised draft of the Standards and Guidelines for Cumulative Impact Analysis, which references MassEnviroScreen. The public comment period for the revised draft guidance was open through Friday, February 13, 2026.
- In February 2026, OEJE concluded its public comment period for the MassEnviroScreen tool.
- On March 26, 2026, OEJE conducted a MassEnviroScreen Technical Session to discuss the functionalities of the mapping software and tool.
- On April 15, 2026, OEJE published the final version of the Standards and Guidelines for Cumulative Impact Analysis.
- In May 2026, MassEnviroScreen was finalized and published.

MassEnviroScreen Model

MassEnviroScreen is a GIS-based mapping tool developed and administered by OEJE that uses indicators to produce a MassEnviroScreen Score and provide indicator data for every census block group across the Commonwealth. It is an interactive, cumulative burden mapping tool for Massachusetts. The purpose of a composite indicator is to measure a multi-dimensional concept that cannot be captured by an individual indicator.[24] The MassEnviroScreen score is intended to measure cumulative environmental and social burdens.

The cumulative burden composite indicator follows guidance from the Organization for Economic Co-operation and Development (OECD) and NASEM,[25] and is modeled on the approaches used by California EPA's CalEnviroScreen tool and the Colorado EnviroScreen tool. The California and Colorado tools utilize a 'cumulative impact score' to describe the relative environmental burden of communities across the state and to prioritize those that are most burdened. California defines cumulative impacts as "the exposures, public health or environmental effects from the combined emissions and discharges, in a geographic area, including environmental pollution from all sources, whether single or multi-media, routinely, accidentally, or otherwise released." Impacts consider "sensitive populations and socio-economic factors, where applicable and to the extent data are available." The Colorado tool augments the CalEnviroScreen approach by adding climate risks, which is the approach followed here.

A 'cumulative burden score' in MassEnviroScreen is a numerical value that ranks every community (i.e., census block group) on a scale from 0 to 100. Higher values indicate greater cumulative burden. These values also represent percentile ranks, which means that a community's score indicates the percentage of scores in Massachusetts that are equal to or lower than a given score. For example, a census block group with a score of 75 (75th percentile) means that its cumulative burden score is equal to or higher than 75% of census block groups in the state. In this model, we follow California's example of using a score of 75 (the 75th percentile) as one of the thresholds for identifying the most impacted or 'Burdened Areas.'

MassEnviroScreen uses the census block group as the geographic unit of analysis. Block groups are the second smallest unit in the Census. A census block group is a statistical division of census tracts and consists of clusters of census blocks. Census block groups in Massachusetts generally contain between 350 and 3,200 people. The US Census Bureau uses these boundaries to summarize data from its Decennial

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[24] OECD, *Handbook on Constructing Composite Indicators*.

[25] OECD, *Handbook on Constructing Composite Indicators*; National Academies of Sciences, Engineering, and Medicine, *Constructing Valid Geospatial Tools for Environmental Justice*.

Census and from the annual American Community surveys. A census block group is the smallest division of U.S. Census data that provides detailed demographic data such as household income, educational attainment, English language isolation, or unemployment information. The census block group provides a higher resolution or more granular view than a census tract, ZIP code, or municipality can.

MassEnviroScreen uses the 2020 census block group boundaries from the US Census. Massachusetts is divided into 5,116 census block groups.

Census block groups with a minimum score of 75 experience cumulative burdens that are equal to or higher than 75% of block groups in the state. In other words, these block groups represent the top 25% of cumulative burden scores in Massachusetts.

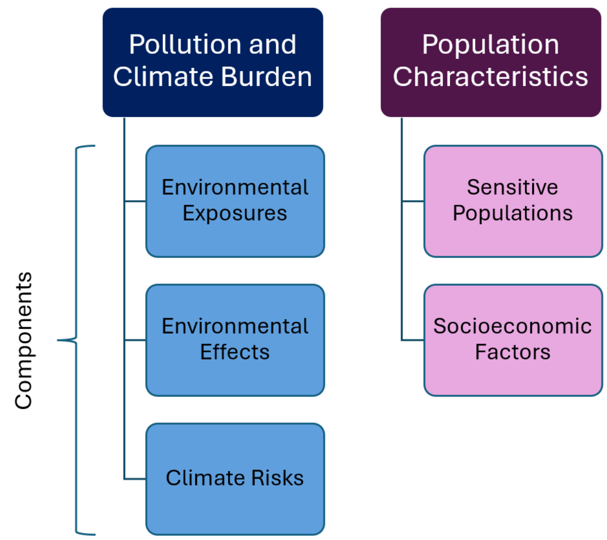
Burdened Areas are communities (i.e., census block groups) that meet one or more of the following criteria:

- cumulative burden percentile score (i.e, MassEnviroScore) of 75 or greater, OR
- annual median household income is 65 percent or less of the statewide annual median household income

Scoring Methodology

The MassEnviroScreen cumulative burden score model is based on three components that represent Pollution and Climate Burden – Exposures, Environmental Effects, and Climate Risks – and two components that represent Population Characteristics – Sensitive Populations (e.g., in terms of health status) and Socioeconomic Factors.

Figure 1 - MassEnviroScreen components



Model Characteristics

The model:

- Uses 30 statewide indicators to characterize Pollution and Climate Burden and Population Characteristics
- Uses percentiles to assign scores for each of the indicators in a given geographic area. The percentile represents a relative score for the indicators. **Please note: A higher percentile score does not necessarily mean that the indicator exceeds regulatory thresholds or poses direct human health risks at that score.**
- Uses a scoring system in which the percentiles are averaged for the set of indicators in each of the five components (Exposures, Environmental Effects, Climate Risks, Sensitive Populations, and Socioeconomic Factors).
- Combines the component scores to produce a MassEnviroScreen score for a given area relative to other areas in the state, using the formula in Figure 3.

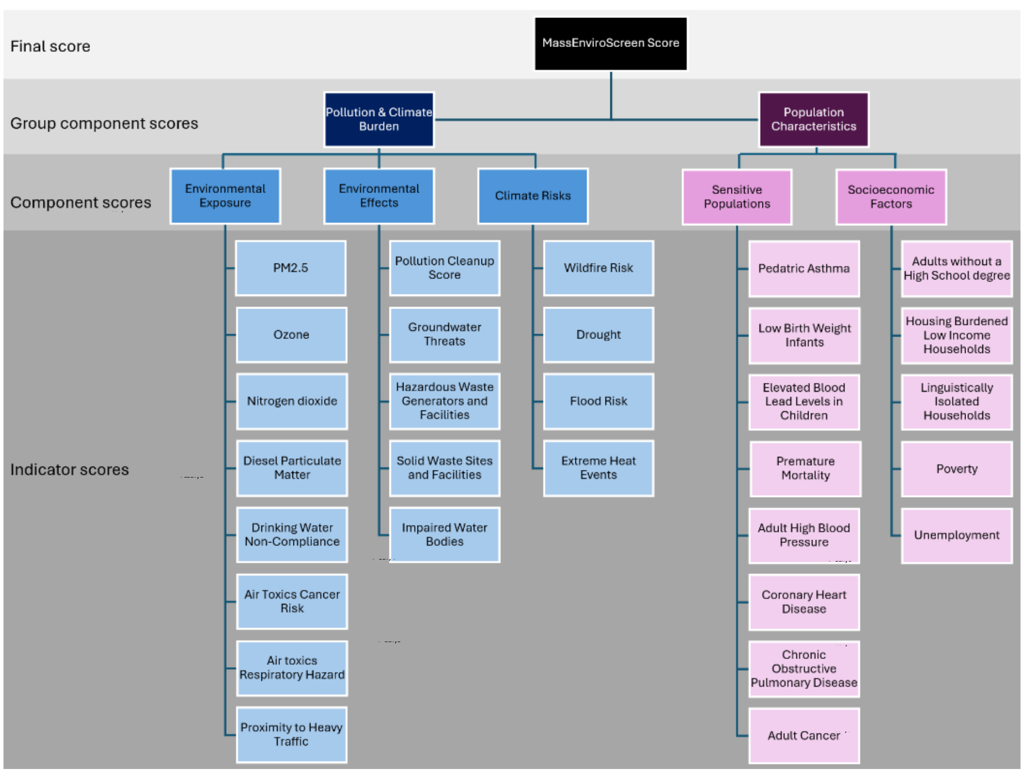
MassEnviroScreen Indicators and Components

An “indicator” is a statistical measure, which is used to evaluate a census block group’s environmental exposures, environmental effects, climate effects, sensitive populations, and socioeconomic factors. Indicators were selected based on their association with cumulative health impacts and social vulnerability based on peer reviewed literature, input from environmental and public health experts, input from community and industry stakeholders, and prevailing practice by other government agencies across the country. Indicator selection was restricted to those datasets that are:

- publicly available,
- derived from official or authoritative sources of data,
- updated on a regular basis,
- represent statewide concerns (i.e., not just localized to a specific region), and
- available at, or able to be aggregated to, census block groups.

The MassEnviroScreen score model is computed from 30 statewide environmental, socioeconomic, and health indicators. MassEnviroScreen indicators are grouped into five broad components, which are further aggregated into two group components, described below. These indicators are listed by category in Figure 2 - MassEnviroScreen Indicators.

Figure 2 - MassEnviroScreen Indicators



Pollution and Climate Burden Indicators

Pollution and Climate Burden indicators refer to those factors that increase the probability of a community being exposed to environmental risks. In the MassEnviroScreen tool, Pollution and Climate Burden indicators are a group component comprised of three components: Environmental Exposures, Environmental Effects, and Climate Risk.

Environmental Exposures

Environmental exposure indicators include factors that could lead to direct population exposure in a geographical location. People may be exposed to a pollutant if they come in direct contact with it, by breathing contaminated air, for example. However, environmental exposure indicators do not provide data on personal or real-time exposure to pollution.

Environmental Effects

Environmental effects indicators refer to environmental factors that have been associated with environmental degradation, ecological effects, and threats to the environment and communities. Environmental effects indicators include factors that could lead to indirect population exposure to an environmental threat or limit a community's ability to use ecosystem resources or services in a geographical location. Environmental effects do not provide personal or real-time exposure to pollution or lack of access to ecosystem resources or services.

Climate Risks

Climate risk indicators refer to climate change risks associated with human health impacts. Climate risk provides a description of the population's risk level. MassEnviroScreen does not provide a personal or real-time estimate of risks due to climate factors.

Population Characteristics Indicators

Population Characteristics indicators refer to those factors that increase biological susceptibilities and social vulnerabilities to environmental exposures and risks. In this tool, Population Characteristics are a group component comprised of two components: Sensitive Populations and Socioeconomic Factors.

Sensitive Populations

These indicators refer to physiological conditions or health status that result in increased susceptibility to environmental risks. Pollutant exposure is a likely contributor to many observed adverse outcomes, and has been demonstrated for some outcomes such as asthma, low birth weight, and heart disease. People with these health conditions are also more susceptible to health impacts from pollution. However, adverse health conditions are difficult to attribute solely to exposure to pollutants.

Socioeconomic Factors

These indicators refer to social determinants of health that are known to produce social vulnerabilities and affect health and are a common source of health and environmental disparities.

Indicator Scoring

Indicator values were normalized by assigning percentile scores based on the order of census block group indicator values from highest to lowest for the entire state. A percentile score was calculated from the ordered values for all block groups that have a score. Each block group's percentile rank for a specific indicator is relative to the ranks for that indicator in the rest of the block groups in the state.

In some circumstances, an indicator may not have data available for every census block group. The MassEnviroScreen Score calculation clearly distinguishes between indicator values of zero and those that are missing or not available ("NA"). A zero value is assumed to represent a valid measure of a specific indicator. For example, a census block group can have zero percent of its area classified as a floodplain. By contrast, an NA value implies that no data was available or possible at this given location. An NA value does not contribute to the component score calculation for a given geography. Because the percentile score ignores NA values, the percentile score can be thought of as a comparison of one geographic area to other localities in the state where the hazard effect or population characteristic is present. This approach to zero values and NA values is consistent with the composite map approaches adopted by the US EPA's EJScreen, FEMA's National Risk Index, CalEnivroScreen, Colorado's EnviroScreen, and other similar state mapping tools.

Each census block group receives scores for as many of the 30 indicators as possible. Although all indicators represent statewide data sources, some census block groups will not have scores for every one of the indicators due to gaps or omissions in the underlying data.

Component Scoring

Indicators from the Environmental Exposures, Environmental Effects, and Climate Risks components were grouped together to represent Pollution and Climate Burden. Indicators from the Sensitive Populations and Socioeconomic Factors components were grouped together to represent Population Characteristics.

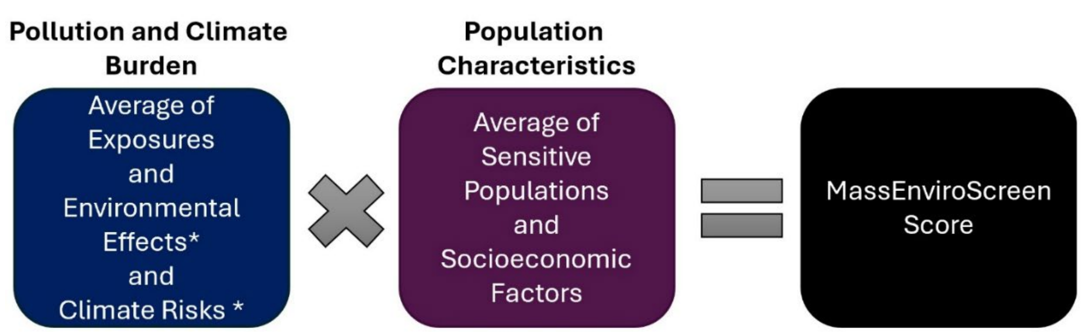
For a given census block group, scores for the Pollution and Climate Burden and Population Characteristics group components are calculated as described below (see example calculation later in this document):

1. The percentiles for all the individual indicators in a component are averaged. This becomes the score for that component. When combining the Environmental Exposures, Environmental Effects, and Climate Risks components, the Environmental Effects and Climate Risks component scores were weighted half as much as the Environmental Exposures component score. This was done because the contribution to possible burden from the Environmental Effects or Climate Risks components is considered less certain or less direct than those from sources in the Environmental Exposures component. The Environmental Effects and Climate Risks components represent the presence of pollutants or risks in a community rather than exposure to them. The Environmental Exposure component receives twice the weight of the Environmental Effects and Climate Risks components.
2. The Population Characteristics score is the average of the Sensitive Population score and Socioeconomic Factors score.
3. The Pollution and Climate Burden and Population Characteristics group component scores are then scaled so that they have a possible range of 0 to 10 with a maximum value of 10.
4. Each group component average is divided by the maximum value observed in the state and then multiplied by 10. The scaling ensures that the Pollution and Climate Burden group component and Population Characteristics group component contribute equally to the overall MassEnviroScreen Score.

Formula for calculating MassEnviroScreen Score

After the components are averaged within Pollution and Climate Burden and Population Characteristics, the group component scores are combined as follows to calculate the overall MassEnviroScreen Score:

Figure 3 – Formula for MassEnviroScreen cumulative burden score



* The Environmental Effects and Climate Risks scores were weighted half as much as the Exposures score.

Scores for the Pollution and Climate Burden and Population Characteristics categories are multiplied (rather than added, for example). Although this approach may be less intuitive than simple addition, there is scientific and practical support for this approach to scoring.

Multiplication was selected for the following reasons:

- *Scientific Literature*: Numerous studies have shown that socioeconomic and sensitivity factors amplify the health risks posed by environmental pollutants and other exposures, making a simple sum less representative of cumulative burden.[26]
- *Risk Assessment Principles*: Some people (such as children) may be many times more sensitive to some chemical exposures than others.[27] Risk assessments apply numerical factors or multipliers to account for potential human sensitivity (as well as other factors such as data gaps) in deriving acceptable exposure levels.[28] This is a commonly adopted approach for capturing the co-occurrence of conditions in which we know or strongly suspect that there is interaction, but the precise nature of that interaction is complex and incompletely understood.
- *Established Risk Scoring Systems*: Priority rankings done by various emergency response organizations to score threats have used scoring systems with the

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[26] Gloria C. Chi et al., "Individual and Neighborhood Socioeconomic Status and the Association between Air Pollution and Cardiovascular Disease," *Environmental Health Perspectives* 124, no. 12 (2016): 1840–47, https://doi.org/10.1289/EHP199; Jane E. Clougherty et al., "The Role of Non-Chemical Stressors in Mediating Socioeconomic Susceptibility to Environmental Chemicals," *Current Environmental Health Reports* 1, no. 4 (2014): 302–13, https://doi.org/10.1007/s40572-014-0031-y; Carolyn Ingram et al., "Cumulative Impacts and COVID-19: Implications for Low-Income, Minoritized, and Health-Compromised Communities in King County, WA," *Journal of Racial and Ethnic Health Disparities* 9, no. 4 (2022): 1210–24, https://doi.org/10.1007/s40615-021-01063-y; Yi Sun et al., "Exposure to Air Pollutant Mixture and Gestational Diabetes Mellitus in Southern California: Results from Electronic Health Record Data of a Large Pregnancy Cohort," *Environment International* 158 (January 2022): 106888, https://doi.org/10.1016/j.envint.2021.106888; Ruipeng Tong and Boling Zhang, "Cumulative Risk Assessment for Combinations of Environmental and Psychosocial Stressors: A Systematic Review," *Integrated Environmental Assessment and Management* 20, no. 3 (2024): 602–15, https://doi.org/10.1002/ieam.4821; Xiangyu Ye et al., "Associations of Socioeconomic Status with Infectious Diseases Mediated by Lifestyle, Environmental Pollution and Chronic Comorbidities: A Comprehensive Evaluation Based on UK Biobank," *Infectious Diseases of Poverty* 12, no. 01 (2023): 1–23, https://doi.org/10.1186/s40249-023-01056-5.

[27] Julia R. Varshavsky et al., "Current Practice and Recommendations for Advancing How Human Variability and Susceptibility Are Considered in Chemical Risk Assessment," *Environmental Health* 21, no. 1 (2023): 133, https://doi.org/10.1186/s12940-022-00940-1.

[28] National Research Council, *Science and Decisions: Advancing Risk Assessment* (The National Academies Press, 2009), https://doi.org/10.17226/12209.

formula: Risk = Threat × Vulnerability.[29] These formulas are widely used and accepted in cumulative burden mapping, in part because multiplication creates a wider range of scores than addition, creating more granularity in differentiating risks and creating distinctions that would be overlooked by addition.

- *Non-compensability*: Multiplication enforces non-compensability, so that a low social vulnerability score cannot fully "cancel" or compensate for a high pollution exposure or climate risk score, and vice versa. Non-compensability is appropriate when it is not possible, or not desirable, to assume that one condition (e.g., high asthma rates) is somehow offset or compensated by another condition (e.g., low climate risk).[30]

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[29] Esther Min et al., "The Washington State Environmental Health Disparities Map: Development of a Community-Responsive Cumulative Impacts Assessment Tool," *International Journal of Environmental Research and Public Health* 16, no. 22 (2019): 4470, https://doi.org/10.3390/ijerph16224470; Yaprak Onat et al., "A State-Specific Approach for Visualizing Overburdened Communities: Lessons from the Connecticut Environmental Justice Screening Tool 2.0," *Sustainability* 17, no. 10 (2025): 10, https://doi.org/10.3390/su17104535; Tim Sheehan et al., "A Comparison of Hazard Vulnerability Indexes for Washington State," *Journal of Homeland Security and Emergency Management* 20, no. 2 (2023): 59–74, https://doi.org/10.1515/jhsem-2021-0066; Margaret M. MacDonell et al., "Characterizing Risk for Cumulative Risk Assessments," *Risk Analysis* 38, no. 6 (2018): 1183–201, https://doi.org/10.1111/risa.12933; ORD US EPA, "Conducting a Human Health Risk Assessment," Reports and Assessments, July 21, 2014, https://www.epa.gov/risk/conducting-human-health-risk-assessment.

[30] National Academies of Sciences, Engineering, and Medicine, *Constructing Valid Geospatial Tools for Environmental Justice*; OECD, *Handbook on Constructing Composite Indicators*.

Example Census Block Group: MassEnviroScreen Score Calculation

One example census block group in Springfield was selected to illustrate how an overall MassEnviroScreen score is calculated and how a community is designated as a Burdened Area. Shown below are:

- A map of a census block group in the Six Corners neighborhood of Springfield, Massachusetts (Figure 4 - Example Census Block Group - highlighted in red). The block group GEOID is 250138019012.
- Tables for the indicators of Pollution and Climate Burden and Population Characteristics with raw and percentile scores for each of the indicators (Figure 5 - Example Score for Pollution and Climate Burdens and Figure 6 - Example Scores for Population Characteristics). Please note: These tables are illustrative and do not necessarily reflect how the raw values and percentiles will appear on the MassEnviroScreen tool.
- A table showing how a MassEnviroScreen score was calculated for this block group (Figure 7 - Example Calculation of MassEnviroScreen Score).

Figure 4 - Example Census Block Group

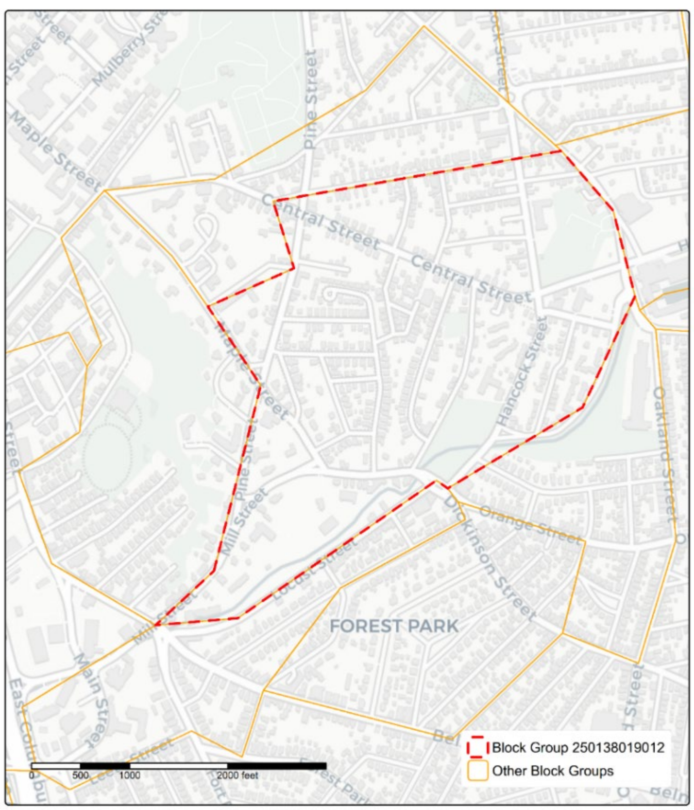

Figure 5 - Example Score for Pollution and Climate Burdens

Block Group 2, Census Tract 8019.01, Hampden County, City of Springfield, "Six Corners Neighborhood"

Exposure Indicators	Raw Value	Percentile
PM2.5	6.92 µg/m^3	90
Ozone (O_3)	65.73 ppb	93
Nitrogen Dioxide (NO_2)	13.07 ppb	84
Diesel Particulate Matter	0.27 µg/m^3	82
Drinking Water Non-Compliance (index)	0	0
Air Toxics Cancer Risk	28.5	96
Air Toxics Respiratory Hazard Index	0.3	79
Proximity to Heavy Traffic (impact index)	4,650,593	53
AVERAGE COMPONENT SCORE		**72.1**

Effects Indicators	Raw Value	Percentile
Pollution Cleanup Sites (weighted count)	66	97
Groundwater Threats (weighted count)	0	0
Hazardous Waste Generators and Facilities (weighted count)	0	0
Solid Waste Sites and Facilities (weighted count)	0	0
Impaired Water Bodies (count of pollutants)	2	65
AVERAGE COMPONENT SCORE		**32.4**

Climate Risks	Raw Value	Percentile
Drought (index)	10.67	25
Wildfire Risk (index)	0	0
Flood Risk	0%	0
Extreme Heat Events	160.5	94
AVERAGE COMPONENT SCORE		**29.8**

Figure 6 - Example Scores for Population Characteristics

Block Group 2, Census Tract 8019.01, Hampden County, City of Springfield, "Six Corners Neighborhood"

Sensitive Populations	Raw Value	Percentile
Pediatric Asthma (prevalence per 100 students K-8)	13.4%	76
Adult High Blood Pressure (prevalence)	38.4	94
Adult Cancer (prevalence)	4.1	5
Coronary Heart Disease (prevalence)	8.2	93
Low Birth Weight Infants (percent of live births)	3.8%	88
Chronic Obstructive Pulmonary Disease (prevalence)	11	97
Elevated Blood Lead Levels in Children (prevalence per 1,000 children 9 – 48 mos)	41.6	94
Premature Mortality (per 100,000 residents)	538.2	94
AVERAGE COMPONENT SCORE		**80.1**

Socioeconomic Factors	Raw Value	Percentile
Adults without a High School Degree	40.2%	98
Housing Burdened Low Income Households	39.6%	99
Linguistic Isolation	17.3%	88
Poverty	37.6%	96
Unemployment	12.6%	90
AVERAGE COMPONENT SCORE		**94.2**

Figure 7 - Example Calculation of MassEnviroScreen Score

Block Group 2, Census Tract 8019.01, Hampden County, City of Springfield, “Six Corners Neighborhood”

	Pollution& Climate Burden			Population Characteristics	
	Exposure	Environmental Effects	Climate Risks	Sensitive Populations	Socioeconomic Factors
1 **Component Scores (average of indicator percentiles)**	72.1	$(0.5 \times 32.4) = 16.2$	$(0.5 \times 29.8) = 14.9$	80.1	94.2
2 **Group Component Scores (average of component scores)**	$\frac{(72.1 + 16.2 + 14.9)}{(1 + 0.5 + 0.5)} = \mathbf{51.6}$ Pollution & Climate Burden is calculated as the average of its three component scores, with the Environmental Effects and Climate Risks components half-weighted			$\frac{(80.1 + 94.2)}{2} = \mathbf{87.2}$ Population Characteristics is calculated as the average of its two component scores	
3 **Scaled Group Component Scores**	$\frac{51.6}{74.5} \times 10 = \mathbf{6.9}$ The Pollution & Climate Burden percentile is scaled by the statewide maximum Pollution Burden score and multiplied by 10 to ensure a maximum value of 10 and a possible range of 0 to 10			$\frac{87.2}{90.9} \times 10 = \mathbf{9.6}$ The Population Characteristics percentile is scaled by the statewide maximum Population Characteristics score and multiplied by 10 to ensure a maximum value of 10 and a possible range of 0 to 10	
4 **MassEnviroScreen Raw Score**	$6.9 \times 9.6 = \mathbf{66.3}$ The scaled Pollution & Climate Burden group component score is multiplied by the scaled value for Population Characteristics group component score to yield a product that is restricted to a range of 0 to 100.				
5 **MassEnviroScreen Ranked Score**	$\frac{Number\ of\ block\ groups\ with\ raw\ scores\ below\ 66.3}{Total\ number\ of\ block\ groups} = \frac{5{,}092}{5{,}116} \times 100 = \mathbf{99.5}$ The rank or percentile of the MassEnviroScreen raw score indicates that more than **99%** of census block groups in Massachusetts have a MassEnviroScreen raw score that is lower than 66.3. In other words, a score of **66.3** puts this census block group in the **99th percentile** or top 1% of all MassEnviroScreen scores statewide.				

Understanding Percentiles

The process for calculating a MassEnviroScreen score for a census block group begins with the 30 indicators shown in Figure 2 - MassEnviroScreen Score Indicators. Because the measurement units of each indicator are unique (e.g., PM2.5 in micrograms per cubic meter, Ozone in parts per billion, etc.), the indicators must be normalized to a common unit of measure to make them comparable and to enable mathematical aggregation. In MassEnviroScreen, indicators are normalized by being converted to percentile values. A percentile value tells us what percentage of census block groups in Massachusetts have a lower value.

For example, the census block group in the Six Corners neighborhood of Springfield (Figure 4 - Example Census Block Group) has a PM2.5 value of 6.92 µg/m^3 (micrograms per cubic meter). Although this value is well below the federal National Ambient Air Quality Standard (“NAAQS”) threshold of 9.0 µg/m^3, it is not clear how the Six Corners neighborhood’s PM2.5 value compares to the rest of Massachusetts. To convert the PM2.5 value into a percentile, we sort the PM2.5 values of every census block group in the state from high to low and then determine what percentage of block groups have PM2.5 values lower than 6.92 µg/m^3. Mathematically, the percentile calculation for a specific value can be represented in the following way:

$$Percentile = \frac{(number\ of\ values\ below\ a\ specific\ value)}{(total\ number\ of\ values)} \times 100$$

In this case, we find that of the total 5,116 block groups across the state, approximately 90% have PM2.5 values lower than 6.92 µg/m^3. We can therefore say that 6.92 µg/m^3

represents the 90th percentile for PM2.5 in Massachusetts, and we can assign a percentile value of 90 to this census block group. This process of percentile normalization is repeated for each of the 30 indicators for every census block group (see Figure 5 - Example Score for Pollution and Climate Burdens and Figure 6 - Example Scores for Population Characteristics). Because percentile values can only range from 0 to 100, all indicators now share a common measurement unit and can be directly compared and aggregated.

Aggregation and Score Calculation

Once all the indicators are normalized to percentiles, the MassEnviroScreen cumulative burden score for a block group is calculated through a series of steps enumerated below and illustrated in Figure 7 - Example Calculation of MassEnviroScreen Score:

Step 1. Five separate component scores are calculated. Each component score represents the mean percentile value of the indicators in that component. For example, the Environmental Exposures component score is the arithmetic mean, or average, of percentile values of the eight indicators in that component (i.e., PM2.5, Ozone, Nitrogen dioxide, etc.)

Step 2. Two group component scores are calculated as the mean of their respective component scores. The Pollution and Climate Burden group component score is a weighted mean of Environmental Exposures, Environmental Effects, and Climate Risks component scores. Environmental Effects and Climate Risks are each half-weighted. The Population Characteristics group component score is the mean of the Sensitive Populations and Socioeconomic Factors component scores, weighted equally.

Step 3. The group component scores are scaled by the statewide maximum group component scores and multiplied by 10 to ensure a maximum value of 10 and a possible range of 0 to 10. In the example census block group in Springfield, the Pollution and Climate Burden group component score is 51.5. This group component score is then scaled, or divided, by the highest Pollution and Climate Burden group component score in the state. In this case, the highest value is 74.5. The result is a proportional value which is then multiplied by 10. The scaling ensures that the Pollution and Climate Burden group and the Population Characteristics components contribute equally to the overall MassEnviroScreen Score.

Step 4. The scaled Pollution and Climate Burden group component score is multiplied by the scaled Population Characteristics group component score to yield a raw MassEnviroScreen score that is restricted to a range of 0 to 100.

Step 5. The raw MassEnviroScreen score is converted to a percentile, yielding the final cumulative burden MassEnviroScreen Score.

Burdened Areas

One of the thresholds for designation as a Burdened Area ("BA") is a MassEnviroScreen cumulative burden score equal to or greater than the 75th percentile for the state.

A census block group may qualify as a BA if it meets any of the following criteria:

- ☑ MassEnviroScreen cumulative impact percentile score of 75 or greater, OR
- ☑ annual median household income is 65 percent or less of the statewide annual median household income

At the 99th percentile, the example Springfield census block group is well above the cumulative impact percentile score of 75 and therefore qualifies as a BA. In addition to the MassEnviroScreen cumulative burden score, this census block group meets the criterion for lower household income. Although a census block group need only exceed one of these thresholds to qualify as a BA, this example block group in Springfield exceeds both thresholds – 75th percentile MassEnviroScreen cumulative burden score and a median household income that is less than 65 percent of the statewide annual median household income.

Limitations of MassEnviroScreen

The MassEnviroScreen tool provides a valuable and transparent resource for understanding cumulative impacts; but it is important to recognize that it is a screening tool with inherent limitations. The tool relies on statewide publicly available datasets, which is a critical component to ensure the tool is transparent and accountable to the public. Publicly available data may not capture every localized condition at a hyper-local scale. Additionally, the spatial resolution of the data, often aggregated to the census block group, means that specific neighborhoods within a block group may experience disproportionately high burdens and social vulnerabilities that are not fully reflected in the MassEnviroScreen score. For these reasons, the MassEnviroScreen is intended as a screening tool and starting point for analysis, to be supplemented with community engagement and local information to provide a complete understanding of cumulative impacts in a given area.

Data Maintenance

OEJE will update the underlying datasets incorporated into MassEnviroScreen on a biennial basis, or every two years, to the extent that updated data is publicly available from the original sources. The purpose of these updates is to incorporate the most recent available data for existing indicators, maintain accuracy in outputs, and ensure transparency regarding data vintages. Data updates will replace existing indicator datasets with newer versions where available but will maintain the existing indicator definitions, weighting structure, methodology and overall framework of the tool. These updates will not introduce new indicators, remove existing indicators, or modify the methodological approach used to calculate scores. As such, these updates are administrative in nature and are intended to keep the tool current and relevant. This maintenance process will not change the structure or methodology of MassEnviroScreen. OEJE does not anticipate a formal public process for these routine data refreshes. However, OEJE will publish updated technical documentation identifying the date of each data source, noting any material changes in data availability, and changes to BA designations. OEJE will also clearly indicate the effective date of each updated version of the tool, maintain an archive of prior versions, and publicly announce updates.

MassEnviroScreen Indicator Descriptions

For each indicator, this section provides the following details: Indicator name, definition, short description, which MassEnviroScreen component group it contributes to, the rationale (why it was selected as an indicator), the method (outlining assumptions and decisions that were made within data processing), years or time period of data source, the original geographic unit or spatial scale of the data, and the data source.

For more information about the original datasets, refer to the data source website/s included in each description.

Please note: A higher percentile score does not necessarily mean that the indicator exceeds regulatory thresholds or poses direct human health risks at that score.

Pollution and Climate Burden - Environmental Exposures

PM2.5

Definition: Average annual 24-hour average concentration of particulate matter that is less than or equal to 2.5 micrometers in diameter ($PM_{2.5}$) measured in micrograms per cubic meter (µg/m^3).

Standard: The federal and Massachusetts health-based standard for annual average PM2.5 is 9.0 µg/m^3 – all of Massachusetts meets this standard. The standard is set by USEPA (and adopted by MassDEP) to protect public health with an adequate margin of safety, including the health of sensitive populations.

Description: PM2.5 is a name for tiny particles (all particles less than 2.5 micrometers in diameter). These particles come from many different sources and have different chemical properties. Sources include vehicle tailpipes, smokestacks, dust from construction sites, fires, and chemical reactions in the atmosphere.

Indicator type: *Environmental Exposures*

Rationale: PM2.5 is one of six widespread air pollutants for which there are national air quality standards to limit their levels in the outdoor air. PM2.5 is an air pollutant that has been associated with the largest disease burden worldwide. PM2.5 is a group of particles from different sources and chemical components. Due to their small size, they have the capacity to be inhaled, travel to the lower respiratory tract, cross the lung-blood barrier, and be transported through the blood to any organ and system in the human body.[31] PM2.5 has been associated with multiple diseases and causes of death in adults and children. PM2.5 has the capacity to produce short and long-term health effects. In the short term, PM2.5 has been linked to pneumonia, cardiac arrhythmia, cardiac arrest, and mortality. In the long-term, PM2.5 exposure in children has been associated with asthma; PM2.5 exposure in pregnant women has been associated with adverse pregnancy outcomes; and PM2.5 exposure in adults has been associated with Alzheimer's disease, chronic kidney disease, chronic obstructive pulmonary disease, dementia, depression, ischemic heart disease, lung cancer, liver cancer, colorectal cancer, respiratory disease, stroke, type 2 diabetes, Parkinson's disease, and mortality, among others.[32] Some people are at disproportionately higher risk of experiencing

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[31] US EPA, "Particulate Matter (PM) Basics," Overviews and Factsheets, April 19, 2016, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.

[32] American Lung Association, "Particle Pollution," accessed July 18, 2025, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution; Cheng-Kuan Lin et al., "Association between Exposure to Ambient Particulate Matters and Risks of Autism Spectrum Disorder in Children: A Systematic Review and Exposure-Response Meta-Analysis," *Environmental Research Letters* 16, no. 6 (2021): 063003, https://doi.org/10.1088/1748-9326/abfcf7; David Rojas-Rueda et al., "Environmental Risk Factors and

health effects from long term exposure to PM2.5, including minorities, children, people with preexisting cardiovascular and respiratory disease, the overweight/obese, current/former smokers, and people with low socioeconomic status.[33]

Method: To estimate PM2.5 concentrations in each census tract USEPA used PM2.5 air quality monitoring data from the State and Local Air Monitoring Stations (SLAMS) and numerical output from the Community Multiscale Air Quality (CMAQ) model into a Bayesian Space-time Downscaling Fusion Model (Downscaler). Fused Air Quality Surface Using Downscaling (FAQSD) output files of daily average PM2.5 values by census tract were downloaded. Average annual 24-hour concentrations were calculated as the mean per census tract. All census block groups received the same PM2.5 measure as the census tract in which they are contained.

Data years: 2022

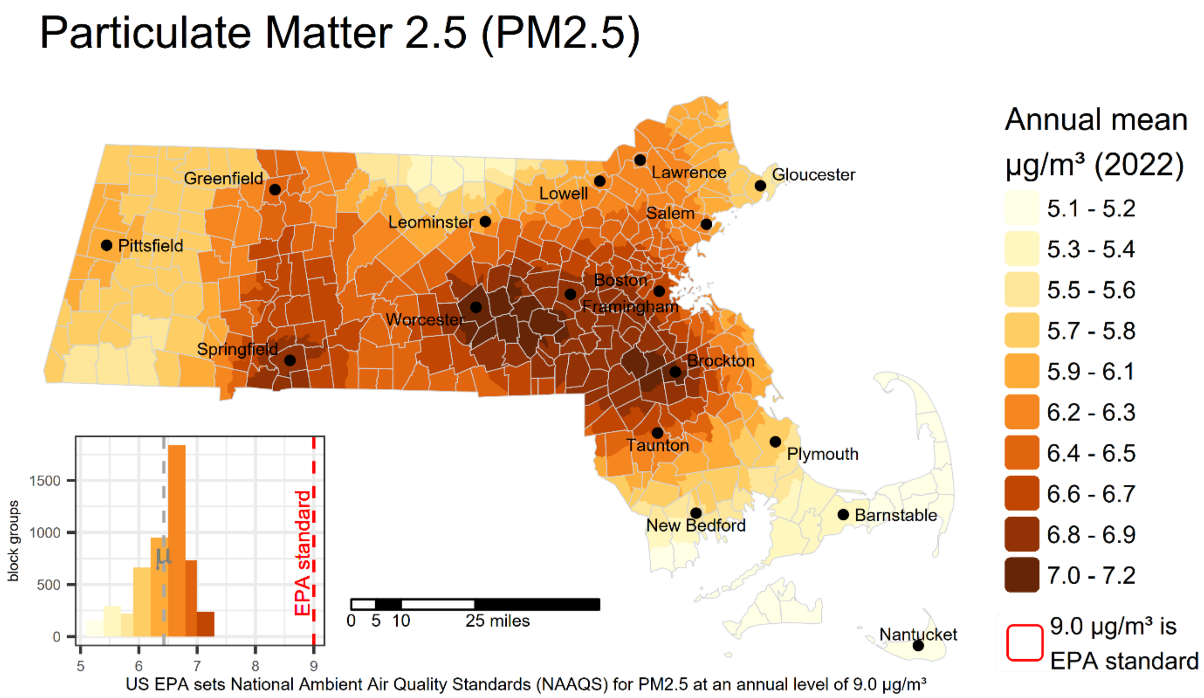
Originating geographic scale of data: census tracts

Source: U.S. Environmental Protection Agency (EPA) Bayesian Space-time Downscaling Fusion Model (Downscaler). https://www.epa.gov/hesc/rsig-related-downloadable-data-files#output

Health: An Umbrella Review of Meta-Analyses," *International Journal of Environmental Research and Public Health* 18, no. 2 (2021): 2, https://doi.org/10.3390/ijerph18020704.

[33] CENTER FOR PUBLIC HEALTH &. ENVIRONMENTAL ASSESSMENT US EPA, "Supplement to the 2019 Integrated Science Assessment for Particulate Matter (Final Report, 2022)," Reports and Assessments, US EPA, April 6, 2022, https://assessments.epa.gov/risk/document/&deid%3D354490.

Figure 8 - Map of raw PM2.5 values



Ozone (O3)

Definition: Maximum 8-hour average model predictions of concentrations of ground-level ozone in parts per billion (ppb).

Standard: The federal and Massachusetts health-based standard for ozone 8-hour average is 70 ppb – all of Massachusetts meets this standard. The standard is set by USEPA (and adopted by MassDEP) to protect public health with an adequate margin of safety, including the health of sensitive populations.

Description: Ground-level ozone is formed from the reaction of oxygen-containing compounds with other air pollutants in the presence of sunlight. Ozone levels are typically at their highest in the afternoon and on hot days.

Indicator type: *Environmental Exposures*

Rationale: Ozone is one of six widespread air pollutants for which there are national air quality standards to limit their levels in the outdoor air. Ozone is an extremely reactive form of oxygen. Ozone has the capacity to directly harm the respiratory tissues when it is inhaled, producing oxidative stress and inflammatory reactions. Ozone exposure has been associated with several acute and chronic respiratory diseases, such as asthma exacerbation, asthma, pneumonia, and respiratory mortality.[34] Over time, ozone can also produce a more systemic inflammatory process, which may contribute to heart disease and mortality, adverse pregnancy outcomes, and neurological diseases. Some people are at higher risk of experiencing health effects from both short-term and long-term exposure to ozone, including children, the elderly, and people with asthma.[35] In addition to its adverse impacts on human health, ozone can also cause harm to public welfare and the economy because it harms plant tissue and interferes with vegetation and crop growth.[36]

Method: To estimate ozone concentrations for each census tract USEPA used daily 8-hour maximum ozone concentrations measured in parts per billion (ppb) from the State and Local Air Monitoring Stations (SLAMS) and numerical output from the Community Multiscale Air Quality (CMAQ) model into the Bayesian Space-time Downscaling Fusion Model (Downscaler). Fused Air Quality Surface Using Downscaling (FAQSD) output files of 8-Hour Ozone Daily Maximum values by census tract were downloaded. The annual mean of the ten highest 8-Hour Ozone Daily Maximum concentrations was

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[34] American Lung Association, "Ozone," accessed July 18, 2025, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/ozone.
[35] US EPA, *Integrated Science Assessment (ISA) for Ozone and Related Photochemical Oxidants*, Other Policies and Guidance EPA/600/R-20/012 (2020), https://www.epa.gov/isa/integrated-science-assessment-isa-ozone-and-related-photochemical-oxidants.
[36] US EPA, "Ground-Level Ozone Pollution," Other Policies and Guidance, May 15, 2015, https://www.epa.gov/ground-level-ozone-pollution.

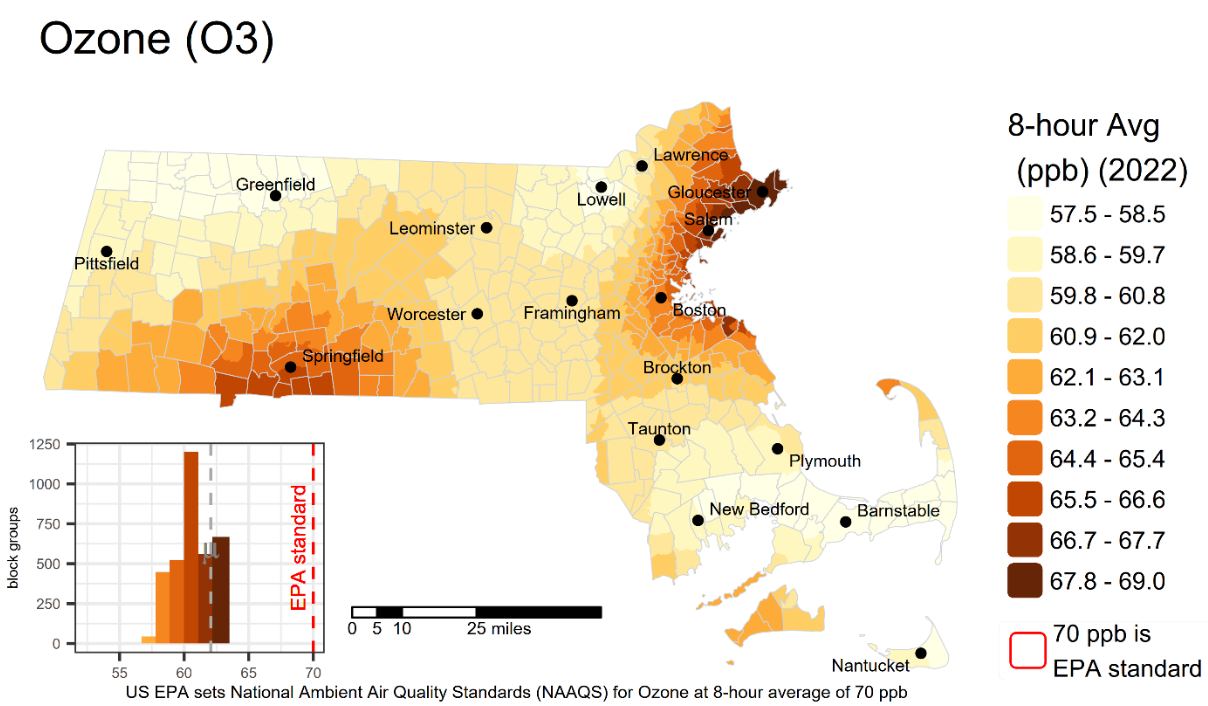
calculated for each census tract. While the Ozone standard for National Ambient Air Quality Standards (NAAQS) is based on the annual 4th highest 8-Hour Ozone Daily Maximum value, here we look at an average across the top ten days which will span days above and below the value of the 4th highest. By looking at an average across multiple days rather than a single day, this metric provides more year-to-year stability while still representing concentrations that correspond to peak ozone exposure. All census block groups received the same ozone value as the census tract in which they are contained.

Data years: 2022

Originating geographic scale of data: census tracts

Source: U.S. Environmental Protection Agency (EPA) Bayesian Space-time Downscaling Fusion Model (Downscaler). https://www.epa.gov/hesc/rsig-related-downloadable-data-files#output

Figure 9 - Map of raw Ozone values



Nitrogen Dioxide (NO2)

Definition: Average annual nitrogen dioxide (NO_2) levels expressed in parts per billion (ppb).

Standard: The federal and Massachusetts health-based standard for annual average NO_2 is 53 ppb – all of Massachusetts meets this standard. The standard is set by USEPA (and adopted by MassDEP) to protect public health with an adequate margin of safety, including the health of sensitive populations.

Description: Nitrogen dioxide, or NO_2, is a gaseous air pollutant composed of nitrogen and oxygen and is one of a group of related gases called nitrogen oxides, or NOx. NO_2 primarily gets into the air from the burning of fuel, such as gasoline, coal, oil, methane gas (natural gas), diesel, or wood. NO_2 forms from emissions from cars, trucks and buses, power plants, and off-road equipment and chemical reactions in the atmosphere.

Indicator type: *Environmental Exposures*

Rationale: Nitrogen dioxide is one of six widespread air pollutants for which there are national air quality standards to limit their levels in the outdoor air. Breathing air with NO_2 concentrations higher than the standard can irritate airways in the human respiratory system.[37] Such exposures over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), hospital admissions and visits to emergency rooms. Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO_2. NO_2 along with other NOx reacts with other chemicals in the air to form both particulate matter and ozone. NO_2 and other NOx interact with water, oxygen and other chemicals in the atmosphere to form acid rain. Acid rain harms sensitive ecosystems such as lakes and forests. NOx in the atmosphere contributes to nutrient pollution in coastal waters.[38]

Method: Source data for the NO_2 indicator are developed by researchers at the Climate and Atmospheric Science for Action research group at Cardiff University and George Washington University for NASA's Health and Air Quality Applied Sciences Team. The NO_2 indicator is developed from a regression model, satellite data, and large-scale models. The resulting product is an approximately one square kilometer grid of

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[37] US EPA, *Integrated Science Assessment (ISA) for Oxides of Nitrogen – Health Criteria (Final Report, Jan 2016)*, Reports & Assessments EPA/600/R-15/068 (2016), https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879.

[38] US EPA, "Basic Information about NO2," Overviews and Factsheets, July 6, 2016, https://www.epa.gov/no2-pollution/basic-information-about-no2.

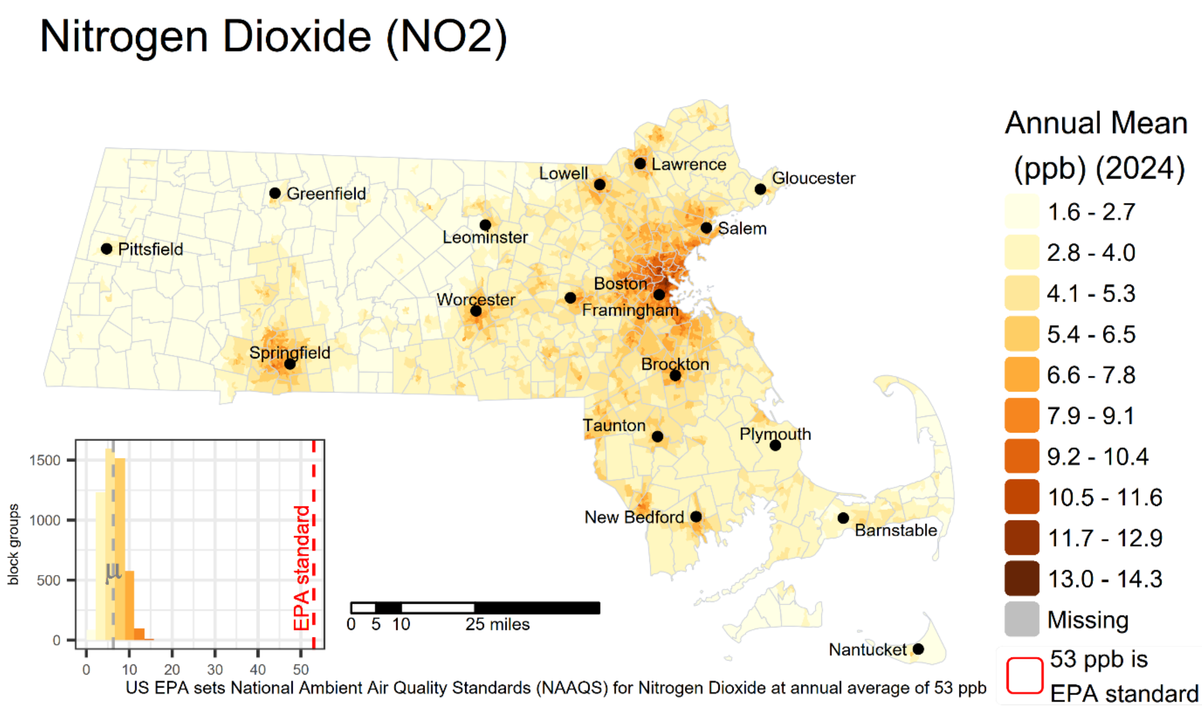
NO_2surface concentrations. Grids covering the continental US were downloaded from the Zenodo data archive as netCDF files. The gridded data was then aggregated to census block group geographies using mean pixel values.

Data years: 2024

Originating geographic scale of data: 1km^2 pixels

Source: Nawaz, M. Omar. “Monthly and Annual US TROPOMI Surface NO2 Estimates (~1km × 1km)”. *Environmental Science and Technology Air*. Zenodo, January 14, 2025. https://doi.org/10.5281/zenodo.14646034. Data available at https://gwu.app.box.com/s/8id0gcje44o9qye1pbe42qw8ce8ioluj?page=4&sortColumn=name&sortDirection=DESC

Figure 10 - Map of raw Nitrogen Dioxide values



Diesel Particulate Matter

Definition: Diesel particulate matter (PM) level in air measured in micrograms per cubic meter (μg/m^3).

Standard: Diesel PM does not have a federal or state health-based standard. USEPA does not include diesel PM in the air toxics cancer risk estimate. The Massachusetts average diesel PM level is 0.176, ranging from 0 to 0.5. The United States average diesel PM level is 0.2, ranging from 0 to 3.0.

Description: Diesel engines emit particles called diesel particulate matter or diesel PM, composed of hundreds of different chemicals. Diesel PM is different from non-diesel particulate matter evaluated as PM2.5. Diesel PM is highest near roadways, freeways, railyards, ports, and other industrial sites where diesel engines are used.

Indicator type: *Environmental Exposures*

Rationale: Short-term exposures to diesel PM can irritate the eyes, nose and throat; cause respiratory effects such as cough; and may exacerbate allergic responses.[39] Long-term exposures to diesel PM can lead to asthma, allergic responses, respiratory illnesses, cardiovascular and pulmonary diseases, and lung cancer. Some people may be at higher risk of experiencing health effects from exposure to diesel PM, including those with asthma, heart and lung diseases, as well as children and the elderly. This measure is included in addition to traffic proximity and the other air pollution indicators to reflect the unique exposure profile that diesel PM produces.

Method: Diesel Particulate Matter concentrations were downloaded from EPA's 2020 AirToxScreen 2020 National Concentration Summaries by Region and aggregated to census block groups.

AirToxScreen was developed by USEPA to provide a “snapshot” of outdoor air quality as it relates to hazardous air pollutants for each state in the continental US. AirToxScreen provides an estimate of the concentration of air toxics in outdoor air. AirToxScreen uses emissions data compiled for a single year as inputs to air quality models. The models use these source data along with meteorological data for the same year to estimate ambient air concentrations of specific air toxics. USEPA then combines these modeled concentrations with census data and other information to calculate exposure concentrations of the air toxics. AirToxScreen then estimates cancer risks and potential noncancer health effects associated with chronic inhalation exposure to the toxics.

[39] US EPA, *Health Assessment Document for Diesel Engine Exhaust*, EPA/600/8-90/057F (2002), https://nepis.epa.gov/Exe/ZyPDF.cgi/300055PV.PDF?Dockey=300055PV.pdf; National Toxicology Program, *Report on Carcinogens, Diesel Exhaust Particles* (2021), https://ntp.niehs.nih.gov/sites/default/files/ntp/roc/content/profiles/dieselexhaustparticulates.pdf.

Detailed description of the AirToxicScreen methodology is available at https://www.epa.gov/AirToxScreen/2020-airtoxscreen-assessment-results .

USEPA's AirToxScreen follows several basic steps to produce the final assessment:

- Compile National Emissions Inventory;
- Estimate ambient concentrations of air toxics across the US;
- Estimate population exposures; and
- Characterize potential public health risks from inhalation exposure.

The National Emissions Inventory (NEI) is a detailed, nationwide inventory of air toxics emissions. The NEI includes emissions from point, nonpoint and mobile sources, as well as emissions from biogenic sources and fires. These source data form the USEPA's air emissions modeling platform and are the foundation of AirToxScreen's air quality modeling. NEI emissions and other necessary data (e.g., meteorological data), are used as inputs to two air quality models used to estimate ambient air concentrations of air toxics: the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) atmospheric dispersion model and the Community Multiscale Air Quality (CMAQ) photochemical model. AERMOD is used for all AirToxScreen air toxics modeled, and CMAQ is used for a list of 52 air toxics that are incorporated into CMAQ multipollutant version 5.4.

AirToxScreen Air Toxics Diesel Particulate Matter ambient concentration data was processed using the following steps:

- Census block-level diesel particulate matter concentration summaries by region were downloaded.
- To aggregate diesel particulate matter concentrations at the census block group level, a population-weighted average of census blocks within each block group was calculated following AirToxScreen 2020 Documentation (p116 Sec 6.4.1. "Aggregation of Block-level Results to Larger Spatial Units"):

$$Conc_{blockgroup_k} = \frac{\sum Conc_{block_i} \times Pop_{block_i}}{Pop_{blockgroup_k}}$$

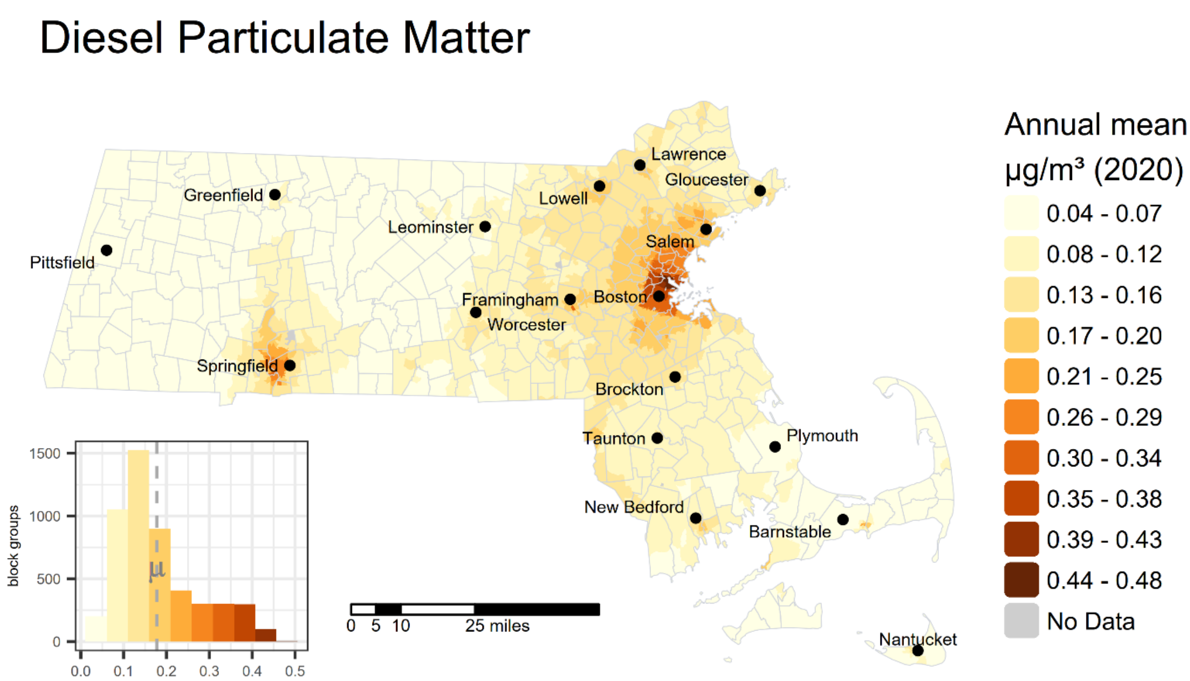
Where:
$Conc_{blockgroup_k}$= population-weighted concentration for block group *k*
$Conc_{block_i}$= ambient concentration in block *i* (contained within block group *k*)
Pop_{block_i} = population in block *i* (contained within block group *k*)
$Pop_{blockgroup_k}$= population in block group *k*

Data years: 2020

Originating geographic scale of data: census block group

Source: U.S. Environmental Protection Agency (EPA) Air Toxics Screening Assessment via EJScreen 2024. https://www.epa.gov/AirToxScreen or https://screening-tools.com/epa-ejscreen

Figure 11 - Map of raw Diesel Particulate Matter values



Drinking Water Non-Compliance

Definition: Safe Drinking Water Act (SDWA) compliance performance score of a community water system (CWS) serving a census block group population.

Context: A Community Water System (CWS) is a public water system that provides water for human consumption through pipes or other constructed conveyances to at least 15 service connections or serves an average of at least 25 people year-round. CWSs are expected to comply with a diverse set of requirements within the National Primary Drinking Water Regulations and the corresponding Massachusetts Drinking Water Regulations. When they do not, violations are issued. This metric assigns a point value to each violation based on how quickly a consumer might see health impact(s). Lower scores are better.

Description: The goal of this indicator is to highlight populations served by community water systems (CWSs) that have challenges complying with National Primary Drinking Water Regulations (NPDWRs). The higher the Drinking Water Non-Compliance Indicator score, the more compliance challenges faced by the CWS(s) serving that census block group population. The drinking water non-compliance indicator distills dozens of different violation types into a single value that attempts to capture the federal Safe Drinking Water Act (SDWA) compliance performance of a CWS. The compliance data used by this indicator does not directly measure drinking water quality as this depends on violation type and other factors unique to each water system. The drinking water non-compliance indicator is only applicable to households that get their drinking water from CWS, which are subject to National Primary Drinking Water Regulations (NPDWRs) under the SDWA. The indicator excludes households on private wells, for example, which are not regulated by the USEPA. The indicator reflects compliance performance for the last 5 years (2021 Q4 to 2025 Q4).

Rationale: Public water systems must meet health-based federal standards for contaminants, including performing regular monitoring and reporting. The Public Water System Supervision or PWSS program is designed to protect public health by ensuring the safety of drinking water. Public water systems are regulated by USEPA, and primacy agencies (states, territories, and Tribes with EPA approval to implement the SDWA) and provide drinking water to 90% of the public. These public drinking water systems, which may be publicly- or privately-owned, serve at least 15 service connections or 25 persons for at least 60 days annually. A Community Water Systems (CWS) is a public water system that supplies water to the same population year-round.[40]

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[40] US EPA. "Information about Public Water Systems." Collections and Lists. September 21, 2015. https://www.epa.gov/dwreginfo/information-about-public-water-systems.

Method: CWS violations for Massachusetts were acquired from the US EPA SDWA Federal Reporting Service (https://sdwis.epa.gov/ords/sfdw_pub/r/sfdw/sdwis_fed_reports_public/200) as SDWIS Data Reports for the last 5 years. All violations pertaining to a common Rule Name within the same reporting period are counted as one violation. For example, a Community Water Supply (CWS) may have received multiple violation notices for different types of Volatile Organic Chemicals (VOCs) within a single reporting period (e.g., benzene, styrene, toluene). Because these contaminants are classified under the same Rule Name (i.e., VOCs), they are treated as one violation during that reporting period. If the same PWS also received violation notices for the same or other VOCs in a subsequent reporting period, the latter would be treated as a second violation, and so on.

Violations are divided into 3 categories with associated point values weighted by severity (based on the three SDWA public notice violation tiers):

1. Health Based Violations (immediate impacts), 10 points:
    a. Nitrate and/or Nitrite Maximum Contaminant Levels (MCLs), Acute Maximum Residual Disinfectant Level (MRDL), Revised Total Coliform Rule (R/TCR) Acute, Turbidity Treatment Technique (TT), Surface Water Treatment Rule Treatment Technique (SWTR TT).
2. Other Health Based Violations, 5 points:
    a. Any other health-based violation (violation type MCL, MRDL or TT), plus Total Coliform Rule TCR Monitoring/Reporting (MR) repeat violations (violation code 25 and 26) and Nitrate MR.
3. Non-Health Based Violations, 1 point:
    a. Any other Monitoring Violation (MON), Reporting Violation (RPT), Monitoring and Reporting (MR), or Other Violations categories.

Public Water Supply service area polygons were acquired from the MassGIS MassDEP Estimated Public Drinking Water System Service Area Boundaries (https://www.mass.gov/info-details/massgis-data-massdep-estimated-public-drinking-water-system-service-area-boundaries). The 5-year service area score of all violation types is first appended into public water supply service area boundaries:

$$Service\ Area\ Score = \sum(Violation\ Severity\ Points)$$

The indicator score is then calculated at the block level and weighted by block population as a percent of its parent block groups' population (see equation below). If any part of the service area boundary is within a block, that block's score gets associated with that service area boundary(ies). If two or more service areas intersect the same block the scores are averaged. This method takes the most health protective approach: theoretically, if only one person is served by a public water system in that block, the score is applied to everyone living in that census block.

$$DWInScore_{blkGrp} = \sum \frac{(DWInScore_{blk})}{n} \times \%\ of\ block\ group\ population$$

The block group score is the sum of the scores calculated at the associated census block level (see equation below). If only one system serves a block group, and the system encompasses all associated block group blocks, the block group score will be identical to the service area score for that system.

$$DWInScore_{blkGrp} = \sum (DWInScore_{blk})$$

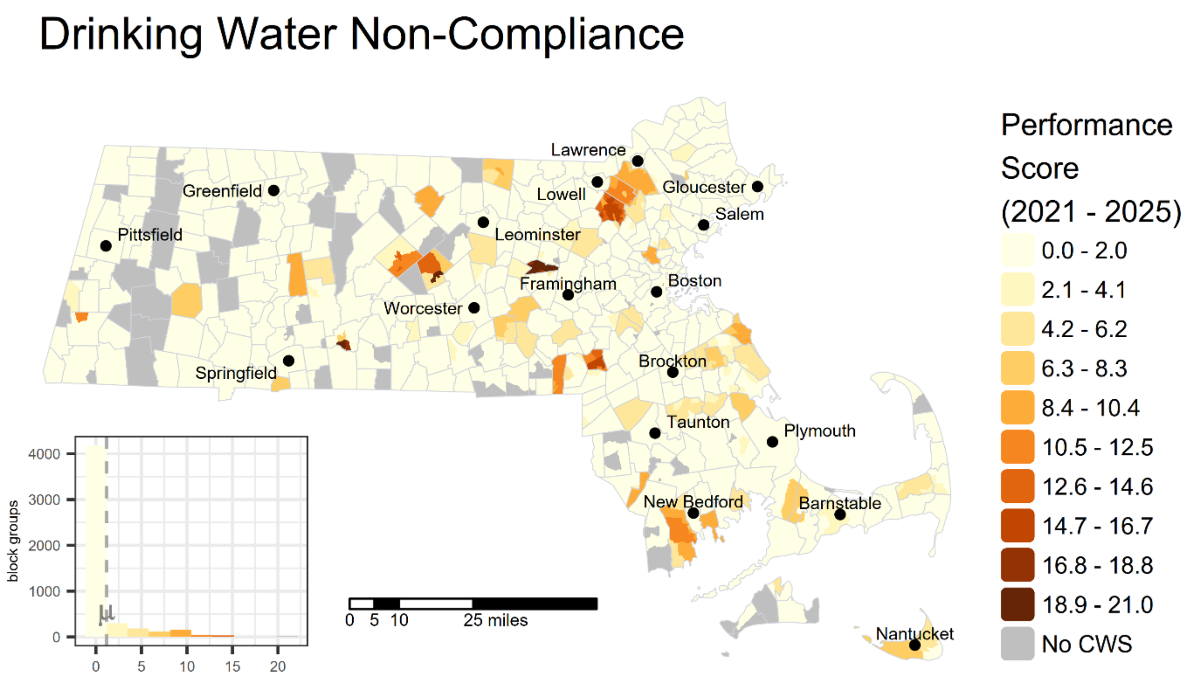
If no service areas intersect any part of a block group, that block group gets a null score. These areas are typically supplied by private well water.

Data years: 2021 - 2025

Originating geographic scale of data: Community Water System areas, Census blocks

Source: US EPA SDWA Federal Reporting Service (Q4 2021 – Q4 2025). https://sdwis.epa.gov/ords/sfdw_pub/r/sfdw/sdwis_fed_reports_public/200; MassGIS MassDEP Estimated Public Drinking Water System Service Area Boundaries (March 2025). https://www.mass.gov/info-details/massgis-data-massdep-estimated-public-drinking-water-system-service-area-boundaries; Census 2020 decennial population counts at block and block group levels via Census API

Figure 12 - Map of Drinking Water non-Compliance raw values



Air Toxics Cancer Risk

Definition: Risk of developing cancer due to inhalation exposure to a group of air toxics over a lifetime of 70 years estimated as cancer cases per million people.

Standard: Air toxics do not have pre-defined federal standards that clearly represent acceptable or unacceptable thresholds of additional lifetime cancer risk. The Massachusetts average lifetime cancer risk from air toxics as a group is 23 per million, ranging from 13 to 152 per million. The United States average lifetime cancer risk is 28 per million, ranging from 6 to 3,272 per million.

Description: USEPA has classified 188 pollutants as Hazardous Air Pollutants (HAPs) as defined in the Clean Air Act. Toxic, or hazardous, air pollutants include gases, such as hydrogen chloride, benzene and toluene; metals such as cadmium, mercury and chromium; and physical agents such as asbestos. Major sources of toxic air pollutants outdoors include emissions from coal-fired power plants, industries, and refineries, as well as from cars, trucks and buses.

Indicator type: *Environmental Exposures*

Rationale: Hazardous air pollutants, also known as toxic air pollutants or air toxics, are pollutants that are known or suspected to cause cancer or other serious health effects. The health effects from air toxics depend on the specific pollutant, the exposure levels, and the duration of exposure. People exposed to toxic air pollutants at sufficient concentrations and durations may have an increased chance of getting cancer or experiencing other serious health effects. Some people are at a higher risk of experiencing health effects from both short-term and long-term exposure to air toxics, including children, the elderly, and people already experiencing health challenges.

Method: AirToxScreen was developed by USEPA to provide a "snapshot" of outdoor air quality as it relates to hazardous air pollutants for each state in the continental US. AirToxScreen provides an estimate of the concentration of air toxics in outdoor air and calculates the associated cancer risk and non-cancer hazard for each individual air toxic and air toxics as a group for each census block group. The cancer risk and non-cancer hazard estimates assume that exposures are chronic (assumed to be a 70-year lifetime) and the concentrations estimated for the "snapshot" year remain the same during the lifetime.

AirToxScreen uses emissions data compiled for a single year as inputs to air quality models. The models use these source data along with meteorological data for the same year to estimate ambient air concentrations of specific air toxics. USEPA then combines these modeled concentrations with census data and other information to calculate exposure concentrations of the air toxics. AirToxScreen then estimates cancer risks and potential noncancer health effects associated with chronic inhalation exposure to the toxics. Detailed description of the AirToxicScreen methodology is available at https://www.epa.gov/AirToxScreen/2020-airtoxscreen-assessment-results .

USEPA's AirToxScreen follows several basic steps to produce the final assessment:

- Compile National Emissions Inventory;
- Estimate ambient concentrations of air toxics across the US;
- Estimate population exposures; and
- Characterize potential public health risks from inhalation exposure.

The National Emissions Inventory (NEI) is a detailed, nationwide inventory of air toxics emissions. The NEI includes emissions from point, nonpoint and mobile sources, as well as emissions from biogenic sources and fires. These source data form the USEPA's air emissions modeling platform and are the foundation of AirToxScreen's air quality modeling. NEI emissions and other necessary data (e.g., meteorological data), are used as inputs to two air quality models used to estimate ambient air concentrations of air toxics: the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) atmospheric dispersion model and the Community Multiscale Air Quality (CMAQ) photochemical model. AERMOD is used for all AirToxScreen air toxics modeled, and CMAQ is used for a list of 52 air toxics that are incorporated into CMAQ multipollutant version 5.4.

AirToxScreen Air Toxics Cancer Risk data was processed using the following steps:

- Census block-level cancer risk by region and source group values were downloaded.
- To compute cancer risks resulting from exposure to multiple air toxics, chronic cancer risk for all air toxic source groups were summed for each census block, following AirToxScreen 2020 Documentation (p113 Sec 6.2.2. "Multiple-pollutant Risks"):

  $Risk_{tot} = Risk_1 + Risk_2 + \ldots + Risk_i$

  Where:

  $Risk_{tot}$ = total cumulative individual lifetime cancer risk, across *i* substances
- To aggregate cancer risk values at the census block group level, a population-weighted risk average of census blocks within each block group was calculated following AirToxScreen 2020 Documentation (p116 Sec 6.4.1. "Aggregation of Block-level Results to Larger Spatial Units"):

$$Conc_{blockgroup_k} = \frac{\sum Conc_{block_i} \times Pop_{block_i}}{Pop_{blockgroup_k}}$$

  Where:

  $Conc_{blockgroup_k}$= population-weighted concentration for block group *k*

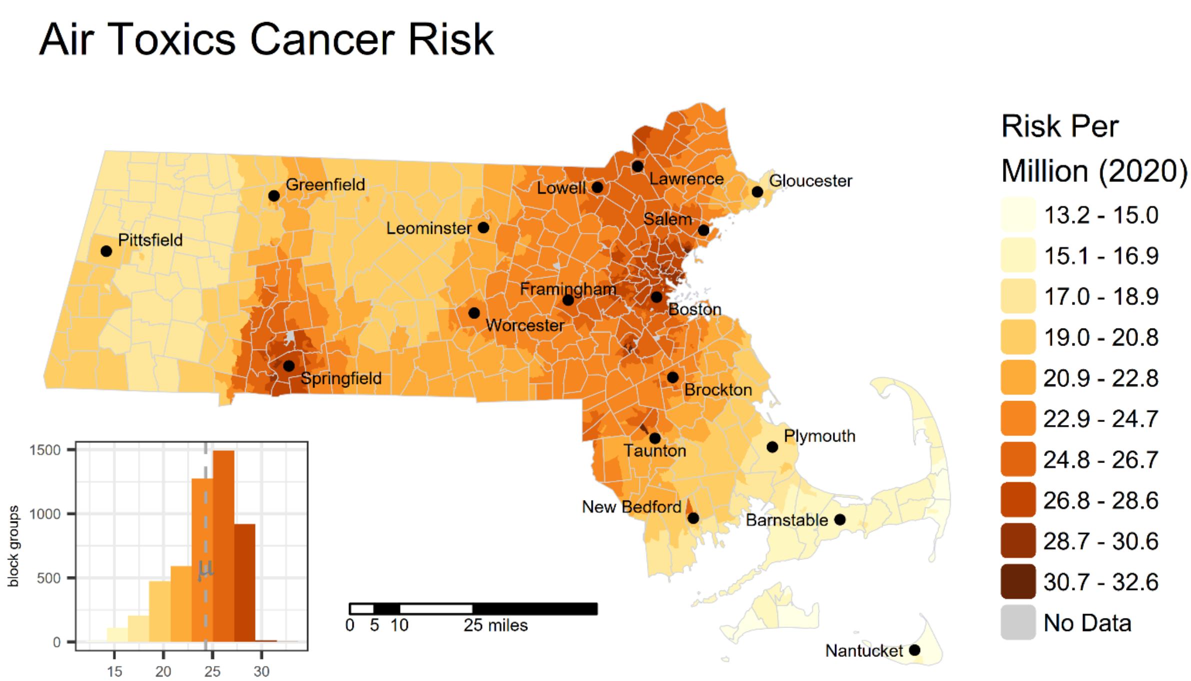
$Conc_{block_i}$= ambient concentration in block *i* (contained within block group *k*)
Pop_{block_i} = population in block *i* (contained within block group *k*)
$Pop_{blockgroup_k}$= population in block group *k*

Data years: 2020

Originating geographic scale of data: census blocks

Source: US Environmental Protection Agency 2020 AirToxScreen: Assessment Results. https://www.epa.gov/AirToxScreen/2020-airtoxscreen-assessment-results; Census 2020 decennial population counts at block and block group levels via Census API

Figure 13 - Map of Air Toxics Cancer Risk raw values



Air Toxics Respiratory Hazard Index

Definition: Air Toxics Respiratory Hazard Index is an estimate of the potential for respiratory effects other than cancer from exposure to a group of air toxic pollutants. It is the sum of the respiratory effects for each air toxic estimated by the ratio of the exposure concentration to the health-based reference concentration for the specific air toxic.

Standard: Air toxics do not have pre-defined federal standards that clearly represent acceptable or unacceptable thresholds for the respiratory hazard index from a group of air toxics or for individual air toxics. However, a hazard index of one (1) or lower means air toxics are unlikely to cause adverse non-cancer respiratory health effects over a lifetime of exposure. The Massachusetts average air toxics respiratory hazard index is 0.26, ranging from 0.10 to 0.69. The US average air toxics respiratory hazard index from air toxics is 0.30, ranging from 0.05 to 3.91.

Description: USEPA has classified 188 pollutants as Hazardous Air Pollutants (HAPs) defined in the Clean Air Act. Toxic, or hazardous, air pollutants include gases such as hydrogen chloride, benzene and toluene, metals such cadmium, mercury and chromium, and physical agents such as asbestos. Major sources of toxic air pollutants outdoors include emissions from coal-fired power plants, industries, and refineries, as well as from cars, trucks and buses.

Indicator type: *Environmental Exposures*

Rationale: Hazardous air pollutants, also known as toxic air pollutants or air toxics, are pollutants that are known or suspected to cause cancer or other serious health effects. The health effects from air toxics depend on the specific pollutant, the exposure levels, and the duration of exposure. People exposed to toxic air pollutants at sufficient concentrations and durations may have an increased chance of getting cancer or experiencing other serious health effects. Some people are at a higher risk of experiencing health effects from both short-term and long-term exposure to air toxics, including children, the elderly, and people already experiencing health effects.

The Respiratory Hazard Index represents the sum of hazard quotients for the air toxics that target the respiratory system with health effects other than cancer. Past assessment results suggest that the respiratory endpoint (the effect of air toxics on the lungs and the rest of the respiratory system) usually drives non-cancer health effects. A hazard quotient is the ratio of the inhaled exposure concentration for each air toxic to its health-based reference concentration (RfC) for inhalation. The hazard quotients are summed across all air toxics that have effects on the respiratory system to calculate the Respiratory Hazard Index.

A hazard index of 1 or lower means air toxics are unlikely to cause adverse non-cancer health effects over a lifetime of exposure. A hazard index value greater than 1 does not mean that an individual will experience health effects. It indicates an increased potential for health effects over a lifetime of exposure.

Method: AirToxScreen was developed by USEPA to provide a “snapshot” of outdoor air quality as it relates to hazardous air pollutants for each state in the continental US. AirToxScreen provides an estimate of the concentration of air toxics in outdoor air and calculates the associated cancer risk and non-cancer hazard for each individual air toxic and air toxics as a group for each census block group. The cancer risk and non-cancer hazard estimates assume that exposures are chronic (assumed to be a 70-year lifetime) and the concentrations estimated for the “snapshot” year remain the same during the lifetime.

AirToxScreen uses emissions data compiled for a single year as inputs to air quality models. The models use these source data along with meteorological data for the same year to estimate ambient air concentrations of specific air toxics. USEPA then combines these modeled concentrations with census data and other information to calculate exposure concentrations of the air toxics. AirToxScreen also estimates cancer risks and potential non-cancer health effects associated with chronic inhalation exposure to the toxics. Detailed description of the AirToxicScreen methodology is available at https://www.epa.gov/AirToxScreen/2020-airtoxscreen-assessment-results

USEPA’s AirToxScreen follows several basic steps to produce the final assessment:

- Compile National Emissions Inventory;
- Estimate ambient concentrations of air toxics across the US;
- Estimate population exposures; and
- Characterize potential public health risks from inhalation exposure.

The National Emissions Inventory (NEI) is a detailed, nationwide inventory of air toxics emissions. The NEI includes emissions from point, nonpoint and mobile sources, as well as emissions from biogenic sources and fires. These source data form the USEPA’s air emissions modeling platform and are the foundation of AirToxScreen’s air quality modeling. NEI emissions and other necessary data (e.g., meteorological data), are used as inputs to two air quality models used to estimate ambient air concentrations of air toxics: the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) atmospheric dispersion model and the Community Multiscale Air Quality (CMAQ) photochemical model. AERMOD is used for all AirToxScreen air toxics modeled, and CMAQ is used for a list of 52 air toxics that are incorporated into CMAQ multipollutant version 5.4.

AirToxScreen Air Toxics Respiratory Hazard Index data was processed using the following steps:

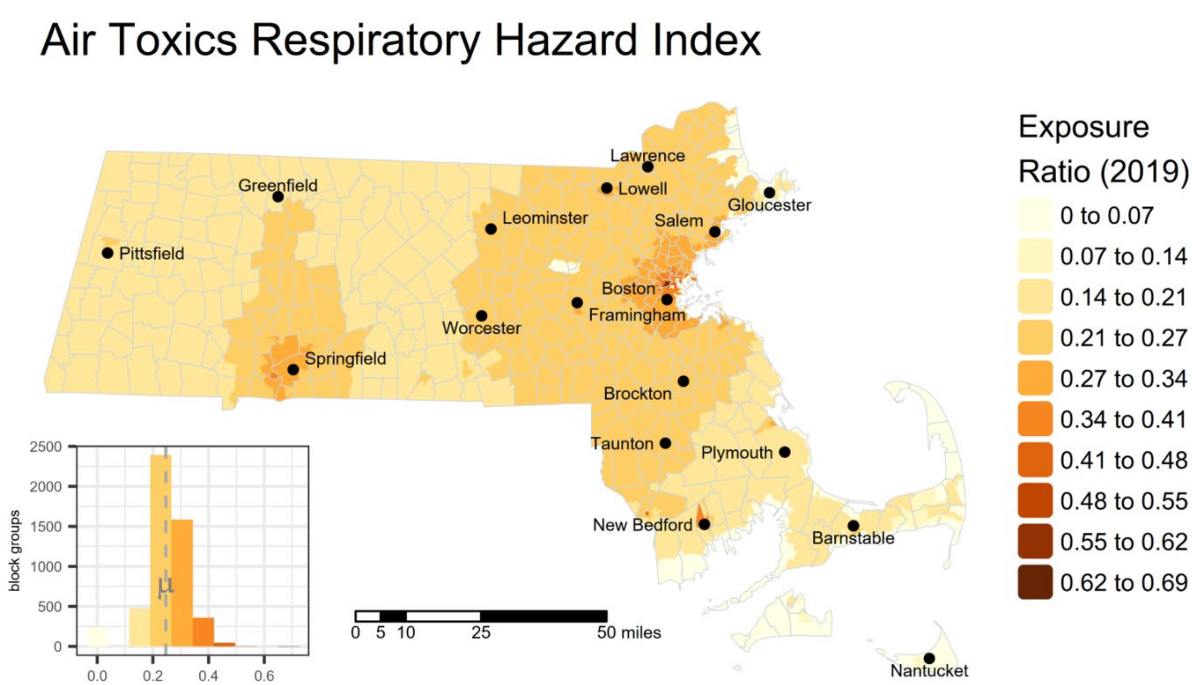
- Tract-level respiratory hazard index by region and source group values were downloaded.
- All census block groups received the same cumulative Respiratory Hazard Index measure as the census tract in which they are contained.

Data years: 2019

Originating geographic scale of data: census tracts

Source: US Environmental Protection Agency 2019 AirToxScreen: Assessment Results. https://www.epa.gov/AirToxScreen/2019-airtoxscreen-assessment-results

Figure 14 - Map of Air Toxics Respiratory Hazard Index raw values



Proximity to Heavy Traffic

Definition: Heavy traffic proximity impact index

Description: Heavy traffic proximity impact index is calculated as the sum of annual average daily traffic (AADT) at major roads within 10 kilometers of a census block centroid, divided by distance (major roads being interstates, principal arterials/other expressways, and minor arterials in urban areas).

Indicator type: *Environmental Exposures*

Rationale: Traffic is a significant source of air pollution, particularly in urban areas, where more than 50% of particulate emissions come from traffic. Exhaust from vehicles contains a number of toxic chemicals, including nitrogen oxides, carbon monoxide, and benzene.[41] Traffic exhaust also plays a role in the formation of ozone. Health effects of concern from these pollutants include heart and lung disease, cancer, and increased mortality.

Method: The traffic proximity indicator is based on AADT count divided by distance in meters from each census block centroid. The proximity score is based on the traffic within a search radius of 10 km. The closest traffic is given more weight, and the distant traffic is given less weight, through inverse distance weighting. The traffic proximity indicator values for each block centroid are averaged to the census block group in which they are contained.

Highway segments are from the HPMS lines and AADT counts are from the 2020 HPMS release, Federal Highway Administration (FWHA), U.S. Department of Transportation (DOT). Proximity scores were calculated by adding a 10km buffer to all non-zero population block groups; performing a one-to-many spatial join to identify all block group-segment pairs; assigning inverse distance scores for all identified 2020 Census blocks within each targeted block group with AADT multiplier (max score of 10); multiplying the scores by AADT and block population weights; and then aggregating the block scores to create a final block group score.

Data years: 2020

Originating geographic scale of data: census block groups

Indicator type: *Environmental Exposures*

Source: EJScreen 2024 at https://screening-tools.com/epa-ejscreen

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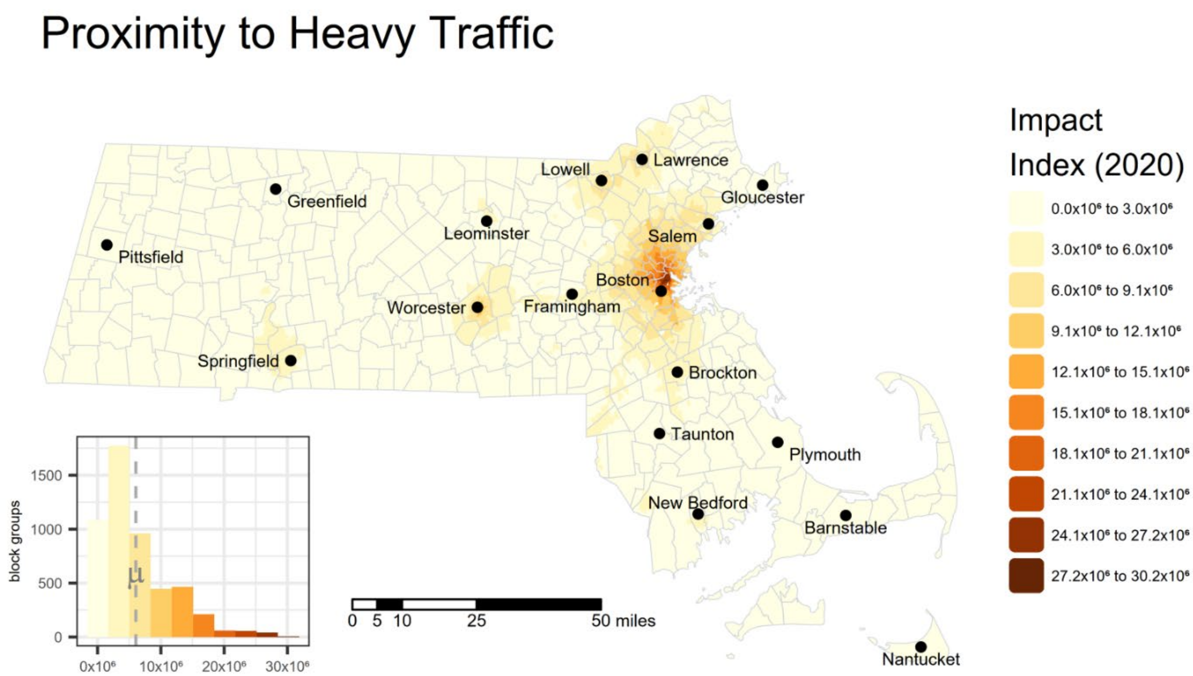
[41] Laura August et al., *CalEnviroScreen 4.0 Report* (California Environmental Protection Agency, 2021); EPA, "Technical Documentation for EJSCREEN," U.S. Environmental Protection Agency, 2019, https://www.epa.gov/ejscreen/technical-documentation-ejscreen.

Figure 15 - Map of Proximity to Heavy Traffic impact index raw values



Pollution and Climate Burden - Environmental Effects

Pollution Cleanup Sites

Definition: Weighted count of environmental cleanup sites requiring federal or state oversight for cleanup due to contamination.

Description: On average, there are about 1,000 new releases of oil or hazardous materials every year which need to be remediated. Types of releases vary from small oil spills to discovering historic contamination. Most releases are cleaned up within one year and over ninety percent of releases are cleaned up within six years. Sites undergoing cleanup actions by governmental authorities or by property owners have suffered environmental degradation due to the presence of hazardous substances. Of primary concern is the potential for people to come into contact with these substances. Some, such as "brownfield" sites, are also underutilized due to cleanup costs or concerns about liability. Since the nature and the magnitude of the threat and burden posed by hazardous substances vary among the different types of sites as well as the site status, the indicator takes both into account. Weights were also adjusted based on proximity to populated census blocks.

Indicator type: *Environmental Effects*

Rationale: Contaminated sites can pose a variety of risks to nearby residents. Hazardous substances can move off-site and impact surrounding communities through volatilization, groundwater plume migration, or windblown dust. Studies have found levels of organochlorine pesticides in blood[42] and toxic metals in house dust,[43] as well as PFAS that were correlated with residents' proximity to contaminated sites.[44]

Method: Geospatial data for federal superfund sites, brownfields sites, Massachusetts MassDEP Tier Classified Oil and/or Hazardous Material Sites (21E sites), MassDEP Oil and/or Hazardous Material Sites with Activity and Use Limitations (AUL sites) were downloaded from their respective agency websites. 21E and AUL sites were screened to remove duplicates based on RTN ID. Brownfields were excluded if they overlapped within 30 meters (~100 feet) of 21E or AUL sites or superfund sites. Sites were scored on a weighted scale of 0 to 12 in consideration of both site risk and status. Higher

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[42] Shannon H. Gaffney et al., "Influence of Geographic Location in Modeling Blood Pesticide Levels in a Community Surrounding a U.S. Environmental Protection Agency Superfund Site," *Environmental Health Perspectives* 113, no. 12 (2005): 1712–16, https://doi.org/10.1289/ehp.8154.

[43] Ami R. Zota et al., "Metal Sources and Exposures in the Homes of Young Children Living near a Mining-Impacted Superfund Site," *Journal of Exposure Science & Environmental Epidemiology* 21, no. 5 (2011): 495–505, https://doi.org/10.1038/jes.2011.21.

[44] Shiwen Li et al., "Examining Disparities in PFAS Plasma Concentrations: Impact of Drinking Water Contamination, Food Access, Proximity to Industrial Facilities and Superfund Sites," *Environmental Research* 264 (January 2025): 120370, https://doi.org/10.1016/j.envres.2024.120370.

weights were applied to Superfund and Chapter 21E sites where there was known groundwater contamination or an imminent hazard. Similarly, higher weights were applied to sites that are undergoing active remediation and oversight, relative to those in which no further action was required. The weights for all sites were adjusted based on the distance they fell from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis. Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given census block group. Each census block group was scored based on the sum of the adjusted weights. Summed census block group scores were sorted and assigned percentiles based on their position in the distribution. The table below shows the weights for each site type.

Data years: National Priorities List and Superfund Alternative Approach Sites 2024; EPA ACRES brownfield sites 2025; MA DEP 21E sites 2025; MA DEP AUL sites 2025

Originating geographic scale of data: point locations

Weighting Matrix for Cleanup Sites

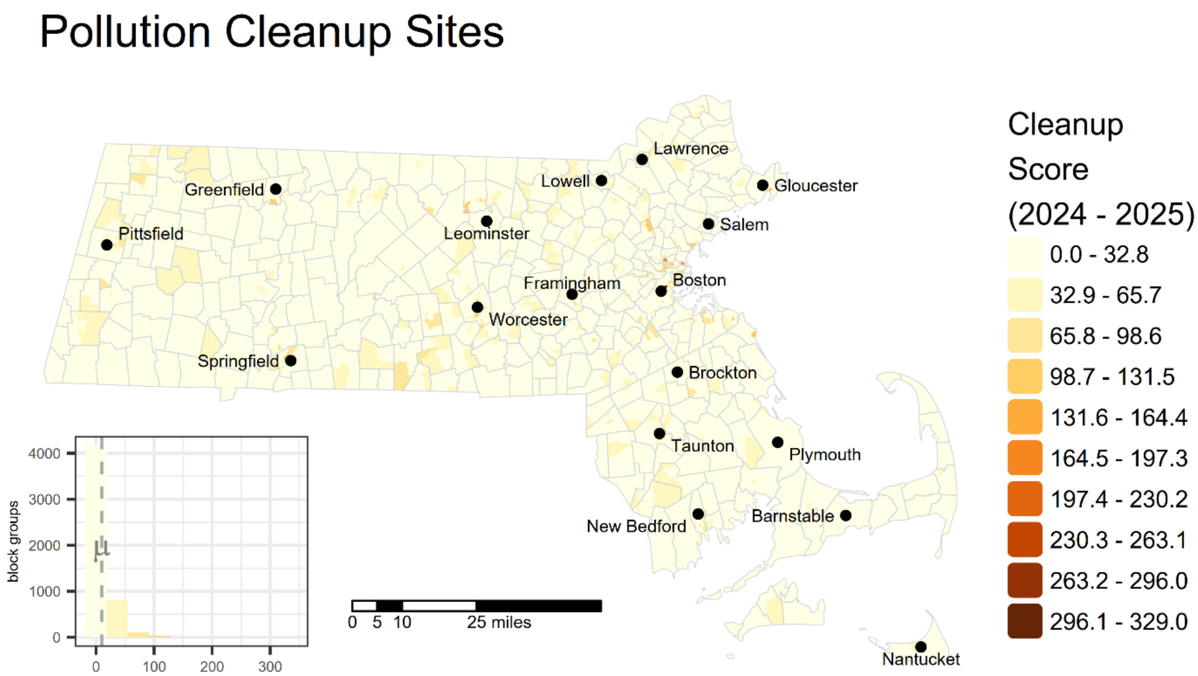
		Status		
		Low • Certified • Completed • No Further Action	Medium • Inactive – Needs Eval. • Certified Operation & Maintenance • Land Use Restrictions	High • Active • Inactive – Action Required
Risk Levels	Low • No Significant Risk	**0**	**4**	**6**
	Medium • Not a substantial hazard but not “No Significant Risk” • Suspected Contamination	**1**	**7**	**9**
	High • Superfund • Groundwater contamination • Imminent hazard	**2**	**10**	**12**

Classifications:

- *Active*: Identifies that an investigation and/or remediation is currently in progress and that DEP is actively involved, either in a lead or support capacity.
- *Certified Operation and Maintenance (O&M)*: Identifies sites that have certified cleanups in place but require ongoing O&M activities.
- *Certified*: Identifies completed sites with previously confirmed releases that are subsequently certified by DEP as having been remediated satisfactorily under DEP oversight.
- *Inactive – Action Required*: Identifies non-active sites where DEP has determined that a removal or remedial action or further extensive investigation is required.
- *Inactive - Needs Evaluation*: Identifies inactive sites where DEP has determined an evaluation is required.
- *No Further Action*: Identifies completed sites where DEP determined that the property does not pose a problem to public health or the environment.
- *Superfund*: Identifies sites where the US EPA proposed, listed, or delisted a site on the National Priorities List (NPL).

Sources: Superfund National Priorities List polygons from US EPA Office of Land and Emergency Management (OLEM) at https://edg.epa.gov/data/PUBLIC/OLEM/OLEM-OSRTI/NPL_Boundaries.zip; Brownfields sites from US EPA Assessment, Cleanup and Redevelopment Exchange System (ACRES) at https://catalog.data.gov/dataset/acres-brownfields-properties; MA DEP 21E sites from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-tier-classified-oil-andor-hazardous-material-sites-mgl-c-21e; MA DEP AUL sites from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-oil-andor-hazardous-material-sites-with-activity-and-use-limitations-aul; Census 2020 decennial population counts at block and block group levels via Census API

Figure 16 - Map of Pollution Cleanup Sites raw values



Groundwater Threats

Definition: Weighted count of groundwater threats.

Description: Many activities can pose threats to groundwater quality. These include the storage and disposal of hazardous materials on land and in underground storage tanks at various types of commercial, industrial, and military sites. Such sites include Underground Storage Tanks (USTs) and to a lesser degree facilities with groundwater discharge permits.

Indicator type: *Environmental Effects*

Rationale: The occurrence of storage tanks, leaking or not, provides a good indication of potential concentrated sources of some of the more prevalent compounds in groundwater. For example, the detection frequency of volatile organic compounds (VOCs) found in gasoline is associated with the number of UST sites within one kilometer of a well.[45] The occurrence of chlorinated solvents in groundwater is also associated with the presence of cleanup sites.[46] People who live near shallow groundwater plumes containing VOCs may also be exposed via the intrusion of vapors from soil into indoor air.[47]

Method: Locations of Underground Storage Tanks (USTs) and facilities with groundwater discharge permits were acquired from the US EPA and MassGIS, respectively. Sites were scored on a weighted scale in consideration of the type (see Matrix). The weights for all sites were adjusted based on their distance from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis. Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given block group. Sites outside of a census block group, but less than 1000m from one of that block group's populated blocks were similarly adjusted based on the distance to the nearest block from that block group. Each census block group was scored based on the sum of the adjusted weights for sites it contains or is near.

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[45] Paul J. Squillace and Michael J. Moran, "Factors Associated with Sources, Transport, and Fate of Volatile Organic Compounds and Their Mixtures in Aquifers of the United States," *Environmental Science & Technology* 41, no. 7 (2007): 2123–30, https://doi.org/10.1021/es061079w.

[46] Michael J. Moran et al., "Chlorinated Solvents in Groundwater of the United States," *Environmental Science & Technology* 41, no. 1 (2007): 74–81, https://doi.org/10.1021/es061553y.

[47] Sara Picone et al., "Sensitivity Analysis on Parameters and Processes Affecting Vapor Intrusion Risk," *Environmental Toxicology and Chemistry* 31, no. 5 (2012): 1042–52, https://doi.org/10.1002/etc.1798; Yijun Yao et al., "Examination of the Influence of Environmental Factors on Contaminant Vapor Concentration Attenuation Factors Using the U.S. EPA's Vapor Intrusion Database," *Environmental Science & Technology* 47, no. 2 (2013): 906–13, https://doi.org/10.1021/es303441x.

Data years: USEPA UST Finder 2018-2021; MA DEP Groundwater Discharge Permits 2025

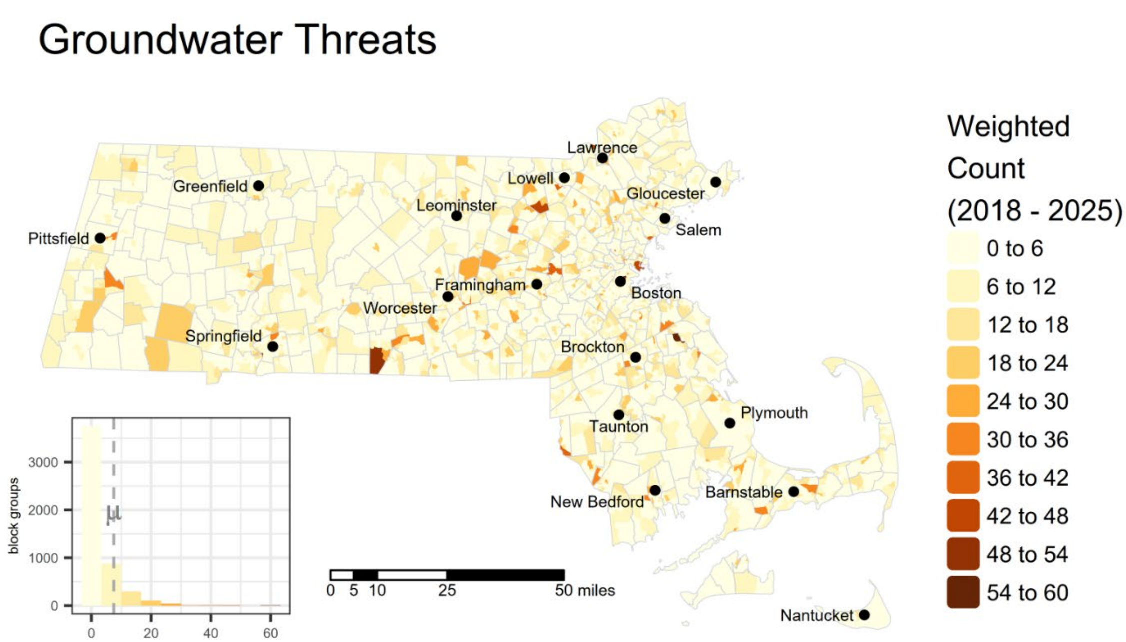
Originating geographic scale of data: point locations

Sources: US EPA's UST Finder data is a national composite of leaking underground storage tanks, underground storage tank facilities, and underground storage tanks as of 2018-2021. Data downloaded via ArcGIS Pro at https://epa.maps.arcgis.com/home/item.html?id=5a3ae0ed53564b6fa519f08e30e79e93 ; MA DEP Groundwater Discharge Permits from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-groundwater-discharge-permits; Census 2020 decennial population counts at block and block group levels via Census API

Weighting Matrix for Groundwater Threats

Site Type	*Status/Type*	*Weight*
Groundwater Discharge Permit Facilities	Industrial, Sanitary Discharge	3
	Car Wash, Laundromat, Reclaimed Water, Other	2
UST Sites	Open	3
	No Further Action	3
	Unknown	3

Figure 17 - Map of Groundwater Threats raw values



Hazardous Waste Generators and Facilities

Definition: Weighted count of hazardous waste facilities, and hazardous waste generators within each census block group.

Description: Most hazardous waste must be transported from hazardous waste generators to permitted recycling, treatment, storage, or disposal facilities (TSDF) by registered hazardous waste transporters. Shipments are accompanied by a hazardous waste manifest. There are widespread concerns for both human health and the environment from sites that serve to process or dispose of hazardous waste. Many newer facilities are designed to prevent the contamination of air, water, and soil with hazardous materials, but even newer facilities may negatively affect perceptions of surrounding areas in ways that have economic, social and health impacts. The Massachusetts Department of Environmental Protection (MassDEP) Bureau of Air and Waste maintains data on permitted facilities that are involved in the treatment, storage, or disposal of hazardous waste as well as information on hazardous waste generators. *Note that the presence of a hazardous waste facility does not mean that there has been any harmful exposure to hazardous waste in the surrounding neighborhoods. The potential for exposure, where it may exist, varies widely across facilities.*

Indicator type: *Environmental Effects*

Rationale: Hazardous waste is, by definition, potentially dangerous or harmful to human health or the environment. The US Environmental Protection Agency and DEP both have standards for determining when waste materials must be managed as hazardous waste. Hazardous waste can be liquids, solids, or contained gases. It can include manufacturing by-products and discarded used or unused materials such as cleaning fluids (solvents) or pesticides. Hexavalent chromium, a hazardous waste of particular human health concern, is generated as part of the chrome plating process.[48] Used oil and contaminated soil generated from a site clean-up can be hazardous waste. Generators of hazardous waste may treat waste onsite or send it elsewhere for disposal. The potential health effects that come from living near hazardous waste disposal sites have been examined in a number of studies.[49] While there is sometimes limited assessment of exposures that occur in nearby populations, there are studies that

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[48] C. Pellerin and S. M. Booker, "Reflections on Hexavalent Chromium: Health Hazards of an Industrial Heavyweight.," *Environmental Health Perspectives* 108, no. 9 (2000): A402–7, https://doi.org/10.1289/ehp.108-a402.

[49] M. Vrijheid, "Health Effects of Residence near Hazardous Waste Landfill Sites: A Review of Epidemiologic Literature.," *Environmental Health Perspectives* 108, no. suppl 1 (2000): 101–12, https://doi.org/10.1289/ehp.00108s1101.

have found health effects, including diabetes and cardiovascular disease, associated with living in proximity to hazardous waste sites.[50]

Method: Permitted facility locations were obtained from the MassGIS data layer MassDEP Major Facilities. Facilities were scored on a weighted scale in consideration of the type, permit status (see Matrix). The weights for all facilities were adjusted based on the distance they fell from populated census blocks. All facilities further than 1,000m from any populated census block were excluded from the analysis. Site weights were adjusted by multiplying the weight by 1 for facilities less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given census block group. Facilities outside of a census block group, but less than 1000m from one of that block group's populated blocks were similarly adjusted based on the distance to the nearest block from that block group. Each census block group was scored based on the sum of the adjusted weights for sites it contains or is near.

Data years: 2024 (updated March 2024)

Originating geographic scale of data: point locations

Source: MassDEP Major Facilities from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-major-facilities; Census 2020 decennial population counts at block and block group levels via Census API

[50] Maria Kouznetsova et al., "Increased Rate of Hospitalization for Diabetes and Residential Proximity of Hazardous Waste Sites," *Environmental Health Perspectives* 115, no. 1 (2007): 75–79, https://doi.org/10.1289/ehp.9223; Alexander V. Sergeev and David O. Carpenter, "Hospitalization Rates for Coronary Heart Disease in Relation to Residence Near Areas Contaminated with Persistent Organic Pollutants and Other Pollutants," *Environmental Health Perspectives* 113, no. 6 (2005): 756–61, https://doi.org/10.1289/ehp.7595.

Weighting Matrix for Permitted Hazardous Waste Facilities and Hazardous Waste Generators

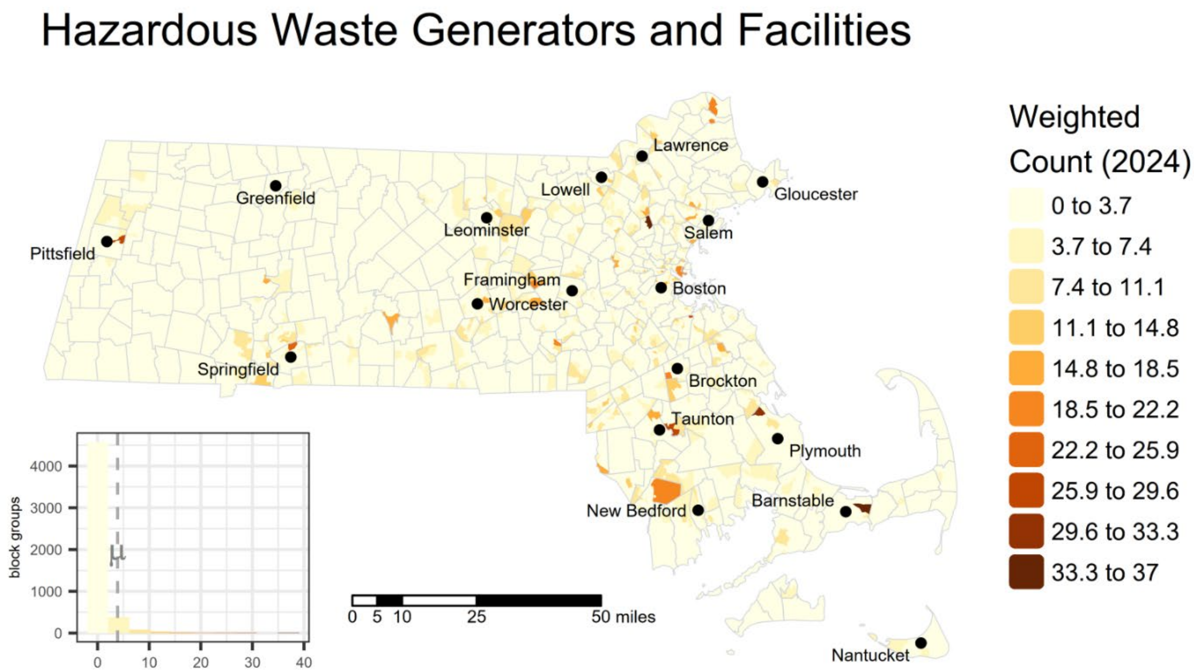
Permitted Hazardous Waste Facilities

Site/Permit Type	*Activity or Status*	*Weight*
Facility Activity (base weight)	Hazardous Waste Treatment, Storage and/or Disposal Facility	10
	Hazardous Waste Recycler	7
Permit Type (additional weight)	Large facilities	1
	Air operating permit	1
	RCRA facilities	2

Hazardous Waste Generators

Generator Type	*Quantity of Waste*	*Weight*
Large Quantity Hazardous Waste Generators OR Large Quantity Toxic User	>1,000 tons/yr	2

Figure 18 - Map of Hazardous Waste Generators and Facilities raw values



Solid Waste Sites and Facilities

Definition: Weighted count of solid waste sites and facilities.

Description: Many newer solid waste landfills are designed to prevent the contamination of air, water, and soil with hazardous materials. However, older sites that are out of compliance with current standards or illegal solid waste sites may degrade environmental conditions in the surrounding area and may expose nearby residents. Other types of facilities, such as composting, treatment and recycling facilities, may raise concerns about odors, vermin, and increased truck traffic. *The presence of a solid waste facility does not by itself mean that there has been any harmful exposure to hazardous pollutants in the surrounding neighborhoods. The potential for exposure, where it may exist, varies widely across facilities.*

Indicator type: *Environmental Effects*

Rationale: Solid waste sites can have multiple impacts on a community. Waste gases like methane and carbon dioxide can be released into the air from disposal sites for decades, even after site closure.[51] Fires, although rare, can pose a health risk from exposure to smoke and ash.[52] Odors and the known presence of solid waste may impair a community's perceived desirability and affect the health and quality of life of nearby residents.[53]

Method: Solid waste site locations were obtained from the MassGIS MassDEP Solid Waste Diversion and Disposal layer. The data includes locations of transfer, incineration and/or land disposal of solid waste in Massachusetts. The weights for all sites, including the large landfill perimeters, were adjusted based on the distance they fell from populated census blocks. Sites further than 1000m from any populated census block were excluded from the analysis. Site weights were adjusted by multiplying the weight by 1 for sites less than 250m, 0.5 for sites 250-500m, 0.25 for sites 500-750m, and 0.1 for sites 750-1000m from the nearest populated census blocks within a given census block group. Sites outside of a census block group, but less than 1000m from one of that tract's populated blocks were similarly adjusted based on the distance to the

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[51] X. F. Lou and J. Nair, "The Impact of Landfilling and Composting on Greenhouse Gas Emissions – A Review," *Bioresource Technology*, Selected papers from the International Conference on Technologies and Strategic Management of Sustainable Biosystems, vol. 100, no. 16 (2009): 3792–98, https://doi.org/10.1016/j.biortech.2008.12.006; Joseph Ofungwu and Steven Eget, "Brownfields and Health Risks—Air Dispersion Modeling and Health Risk Assessment at Landfill Redevelopment Sites," *Integrated Environmental Assessment and Management* 2, no. 3 (2006): 253–61, https://doi.org/10.1002/ieam.5630020305.

[52] FEMA, *Landfill Fires: Their Magnitude, Characteristics, and Mitigation*, FA-225 (US Fire Administration, 2002), https://www.sustainable-design.ie/fire/FEMA-LandfillFires.pdf.

[53] Christopher D. Heaney et al., "Relation between Malodor, Ambient Hydrogen Sulfide, and Health in a Community Bordering a Landfill," *Environmental Research* 111, no. 6 (2011): 847–52, https://doi.org/10.1016/j.envres.2011.05.021.

nearest populated block from that block group. Each census block group was scored based on the sum of the adjusted weights for sites it contains or is near. Summed census block group scores were sorted and assigned percentiles based on their position in the distribution.

Data years: 2024 (updated January 2025)

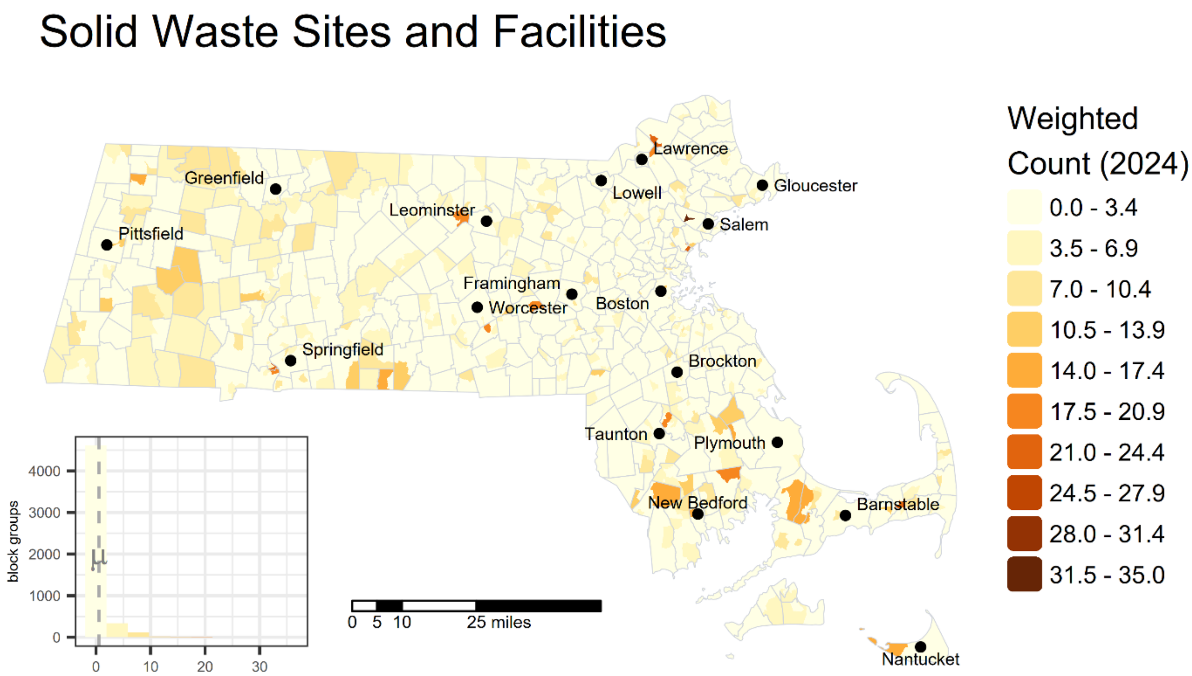
Originating geographic scale of data: point locations

Source: MassDEP Solid Waste Diversion and Disposal layer from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-solid-waste-diversion-and-disposal; Census 2020 decennial population counts at block and block group levels via Census API

Weighting Matrix for Solid Waste Sites and Facilities

Category	*Site or Facility Type*	*Weight*
Waste combustion facility (active)		10
Solid Waste Landfill or Construction, Demolition and Inert (CDI) Debris Waste Disposal (active)		8
Unpermitted Dumping Grounds (inactive)		6
Transfer, processing, handling facility	Permitted large volume, C&D	5
	Permitted small volume, organic or wood waste	2
Waste Tire, recycling, wood waste		4
Composting	Site assigned composting facility	4
	Site assignment exempt composting facility	2
Aerobic/Anaerobic Digesting		3
Solid Waste Disposal Site, historic incinerator or combustion facility (closed, inactive)		1

Figure 19 – Map of Solid Waste Sites and Facilities raw values



Impaired Water Bodies

Definition: Count of pollutants across all water bodies designated as impaired within the area.

Description: The Massachusetts Surface Water Quality Standards define the water quality goals for surface waters by designating the most sensitive uses; prescribe minimum water quality criteria (both numeric and narrative) required to sustain the designated uses; and include provisions to maintain and protect existing uses and high-quality waters. Contamination of streams, rivers, lakes, and coastal waters by pollutants can compromise the use of the water body for drinking, swimming, fishing, aquatic life protection, and other designated uses. When this occurs, such water bodies are considered "impaired." Information on impairments to these water bodies can help determine the extent of environmental degradation within an area.

Indicator type: *Environmental Effects*

Rationale: Rivers, lakes, ponds, estuaries and marine waters in Massachusetts are important for many different uses. Swimming and boating uses can be impacted by high levels of water-borne pathogens and other contaminants. Waterbodies used for recreation may also be important to the quality of life of nearby residents if subsistence fishing is critical to their livelihood. Water bodies also support abundant flora and fauna. Alterations in natural conditions in aquatic environments (e.g., excess nutrients like phosphorous and/or nitrogen, toxics, etc.) can affect biological diversity and overall health of ecosystems. Aquatic species important to local economies may be impacted if the habitats where they seek food and reproduce are changed. Marine wildlife like fish and shellfish that are exposed to toxic substances may potentially expose local consumers to toxic substances as well. Excessive hardness, unpleasant odor or taste, turbidity, color, weeds, and trash in the waters are types of pollutants affecting water aesthetics, which in turn can affect nearby communities.

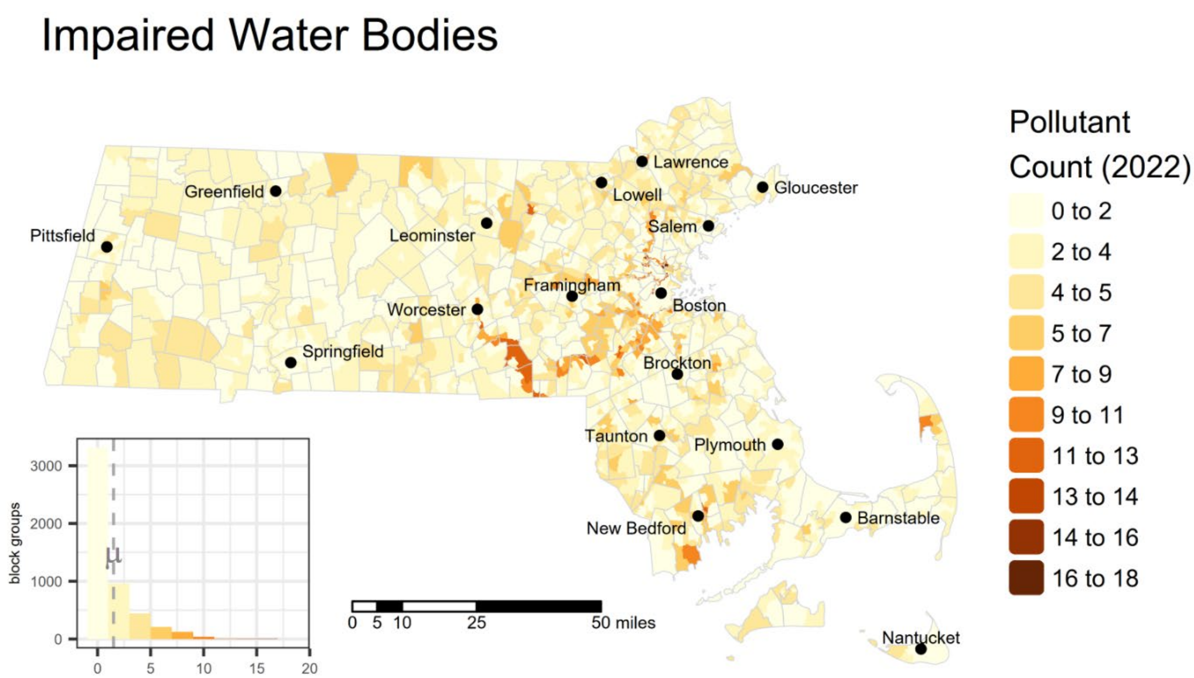
Method: The MassDEP 2022 Integrated List of Waters (305(b)/303(d)) geospatial layer was downloaded from MassGIS (updated August 2023). Water bodies (i.e., Assessment Units) listed as Category 5 "Impaired for one or more uses and requiring a restorative "action" plan, such as a TMDL or Alternative Restoration Plan (impairment due to pollutant(s) such as nutrients, metals, pesticides, solids, and pathogens)" were isolated for analysis. The number of pollutants listed in impaired streams or rivers that fell within 1 kilometer (km) or 2 km respectively of a census block group's populated blocks were counted. The 2 km buffer distance was applied to impaired major rivers (>100 km in length). The 1 km buffer distance was applied to all smaller impaired streams/rivers. The number of pollutants listed in impaired lakes, bays, estuaries or shoreline that fell within 1 km or 2 km of a census block group's populated blocks were counted. The 2 km buffer distance was applied to impaired major lakes or bays greater than 25 square kilometers in size. The 1 km buffer distance was applied for all other impaired lakes/bays. The two pollutant counts were summed for every census block group. Each census block group was scored based on the sum of the number of individual pollutants within impaired water bodies found within and/or bordering the block group. For example, if two stream sections within a census block group were both listed for the same pollutant, the pollutant was only counted once. Summed census block group scores were sorted and assigned percentiles based on their position in the distribution.

Data years: 2022 (updated August 2023)

Originating geographic scale of data: water body linear and polygon features

Source: MassDEP 2022 Integrated List of Waters (305(b)/303(d)) from MassGIS at https://www.mass.gov/info-details/massgis-data-massdep-2022-integrated-list-of-waters-305b303d; Census 2020 decennial population counts at block and block group levels via Census API

Figure 20 - Map of Impaired Water Bodies raw values



Pollution and Climate Burden - Climate Risks

Drought

Definition: Annualized index of drought frequency weighted by drought severity.

Description: A drought is a period of time when an area experiences abnormally dry conditions due to a combination of less than normal rainfall or snowfall and warmer temperatures. Climate change increases the frequency and severity of drought. The goal of this indicator is to communicate drought risk as an index that incorporates both the frequency and severity of drought by community and across the Commonwealth.

Indicator type: *Climate Risks*

Rationale: Drought is an important climate health indicator because it reflects areas with an increased risk of wildfires, dust storms, shortage of local water and food sources, cyanobacterial blooms, poor quality drinking water, and sanitation and hygiene restrictions. Drought can lead to dehydration, stress, anxiety, depression, lung and heart diseases, stroke, and infectious diseases, among other impacts.[54] Severe, extreme, and exceptional drought categories are more likely to impact populations through water shortages, water restrictions, crop or pasture losses, and heightened risk of fire, especially for those living near forests.

Method: The Drought Score is based on the product of a severity-weighted, annualized drought frequency value.

To calculate a severity-weighted, annualized drought frequency value, monthly data on drought status in Massachusetts was acquired from the Massachusetts Drought Management Task Force History of Drought Declarations in Massachusetts webpage (https://www.mass.gov/info-details/history-of-drought-declarations-in-massachusetts). Drought status in Massachusetts is reported by month for the last 25 years, from November 2001 through December 2025. Based on conversations with the Water Resources Division in the Massachusetts Executive Office of Energy and Environmental Affairs, unreported months during the 2001 to 2025 timeframe were imputed to be "normal" or non-drought conditions. Mid-month drought reports were included as separate "months" where available.

Drought status is reported by Drought Region. The Massachusetts Drought Management Plan (DMP) delineates seven Drought Regions for the state. The Drought Regions represent broad geographic areas, originally based on precipitation patterns,

[54] CDC, "Drought and Your Health," Drought and Health, February 14, 2025, https://www.cdc.gov/drought-health/about/index.html.

which have been refined along their boundaries to align with county boundaries. The table below shows the counties corresponding to each of the seven regions.

DROUGHT REGION	COUNTY(IES)
WESTERN	Berkshire
CONNECTICUT RIVER VALLEY	Franklin, Hampshire, and Hampden
CENTRAL	Worcester
NORTHEAST	Essex, Middlesex, and Suffolk (plus town of Brookline)
SOUTHEAST	Bristol, Plymouth, and Norfolk (minus town of Brookline)
CAPE COD	Barnstable
ISLANDS	Nantucket and Dukes (includes Elizabeth Islands)

In some periods, drought conditions are reported on an individual county or watershed basis. This may be particularly useful if drier conditions exist within a watershed or county but not in the entire region(s) in which it is located. Where available, drought status reported by county or watershed are given primacy over the regional status and assigned to the affected census block groups in the calculation of the drought score.

Following the Massachusetts Drought Management Plan, conditions are classified into five levels: a normal condition and four drought severity levels. These levels are based on six drought indices, as well as observed impacts on various resources and forecasts. The condition levels are:

- Level 0-Normal (i.e., No Drought),
- Level 1-Mild Drought,
- Level 2-Significant Drought,
- Level 3-Critical Drought, and
- Level 4-Emergency Drought.

For each Drought Region a severity-weighted, annualized frequency was calculated. Drought condition severity was weighted on a scale of 0 – 4, where

- Level 0-Normal (i.e., No Drought) = 0
- Level 1-Mild Drought (formerly Advisory) = 1
- Level 2-Significant Drought (formerly Watch) = 2
- Level 3-Critical Drought (formerly Warning) = 3
- Level 4-Emergency Drought (formerly Emergency) = 4

For each region, the count of months of each drought condition was multiplied by the respective severity weight and these products were summed for the region. The region’s sum was then divided by the period of record (25 years).

$$RegionSWAF = \frac{\sum(Drought\ months\ \times Severity\ Weight)}{Period\ Record}$$

Where

$RegionSWAF$ is the severity-weighted, annualized frequency value for a specific drought region,

$Drought\ months$ is the number of months that a drought region experienced a given level of drought condition (i.e., Normal, Mild Drought, Significant Drought, etc.),

$Severity\ Weight$ is the drought condition weight listed in the table above, and

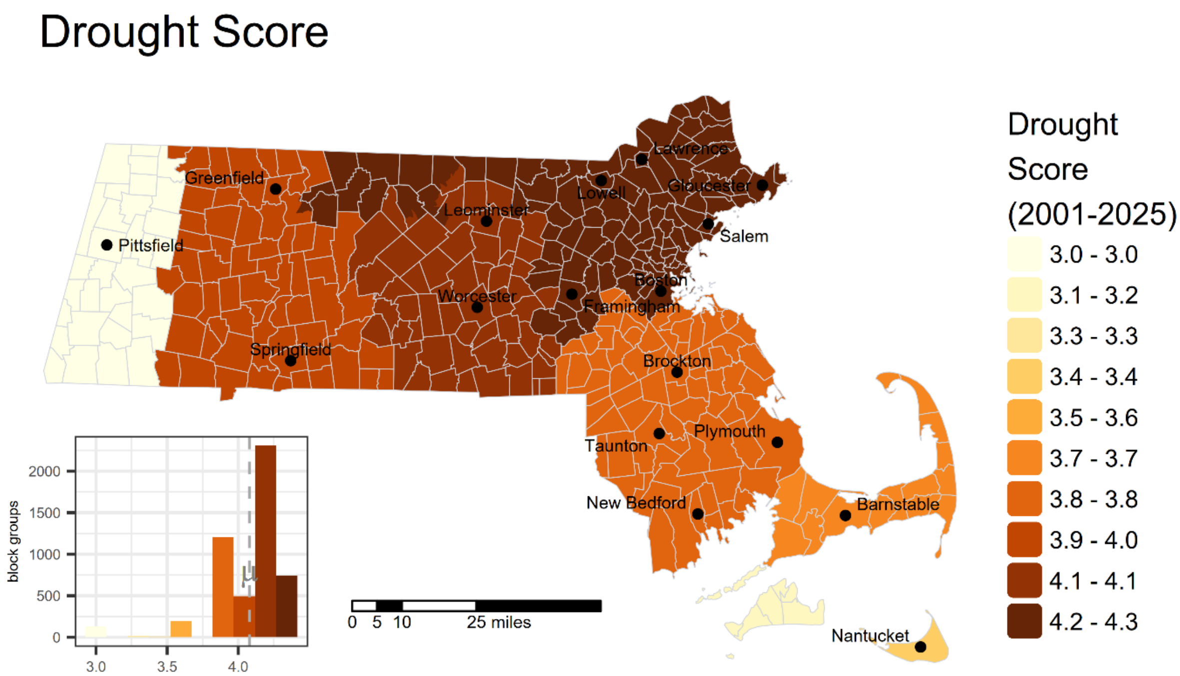
$Period\ Record$ is the period of record, in years, for data on drought conditions (total months divided by 12).

Data years: 2001 - 2025

Originating geographic scale of data: Massachusetts drought regions

Source: Massachusetts Drought Management Plan. December 2023. https://www.mass.gov/info-details/drought-status; History of Drought Declarations in Massachusetts. https://www.mass.gov/info-details/history-of-drought-declarations-in-massachusetts.

Figure 21 - Map of Drought Vulnerability raw values



Wildfire Risk

Definition: Mean Annualized Wildfire Impacts is an index that quantifies risk to Highly Valued Resources or Assets (HVRA) and the likelihood of wildfire.

Description: A wildfire is an uncontrolled fire in nature, such as in forests or grasslands. Wildfires affect people's physical, mental, and financial health. Wildfires threaten ecosystems and water supplies and produce harmful smoke, which can trigger health problems like asthma or stroke. Climate change increases the risk and severity of wildfires. In New England, wildfire risk tends to be greatest at the urban-wildlands interface, where human activity comes into contact with a combustible fuelscape. Annualized Wildfire Impact index values quantify risk to Highly Valued Resources or Assets (HVRA) and the likelihood of wildfire. Highly valued resources and assets (HVRA) include homes, critical infrastructure, historic buildings, and water resources. Index values can be qualitatively classified by severity of risk:

ANNUALIZED WILDFIRE IMPACT INDEX VALUE	DESCRIPTION
Less than -0.001	Extreme
-0.0009999999 to -0.000316	Very High
-0.00031599999 to -0.00001	High
-0.0000099999 to -0.000003	Moderate
-0.00000299999 to -0.0000001	Low
-0.0000000999 to -0.00000001	Very Low
-0.0000000099 to 0	Extremely Low/Neutral

Indicator type: *Climate Risks*

Rationale: Wildfires can lead to direct injuries and death among those living in affected areas.[55] Other health risks can be associated with the evacuation of patients, reduced access to health services, and the impact on the quality and availability of local water resources. Wildfires also produce smoke that impacts communities in the affected areas. The smoke can travel far distances, even reaching communities in other states. Wildfire smoke has been associated with multiple health outcomes, such as adverse pregnancy outcomes, impacts to children's health (e.g., asthma), and impacts to adults (e.g., cardiovascular and respiratory diseases). Exposure to wildfire smoke can ultimately increase the risk of premature mortality.[56] Please note that this indicator does not incorporate the risk of exposure to smoke from wildfires.

Method: This dataset is derived from a 30-m cell size representation of wildfire risk to Highly Valued Resources or Assets (HVRA). Highly valued resources and assets

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[55] FEMA, "Wildfire," accessed July 22, 2025, https://resilience-fema.hub.arcgis.com/pages/wildfire.

[56] CDC, "How Wildfire Smoke Affects Your Body," Wildfires, February 20, 2025, https://www.cdc.gov/wildfires/risk-factors/index.html.

(HVRA) include homes, critical infrastructure, historic buildings, and water resources. This dataset has been multiplied by burn probability and considers the likelihood of wildfire, or “expected” wildfire risk.

This data layer is part of a set of wildfire risk results developed for the Eastern Region All-Lands Quantitative Wildfire Risk Assessment (ERRA), produced by integrating HVRA spatial data, response functions characterizing susceptibility to wildfire, and 30-m fire-effects flame-length probabilities from the WildEST wildfire fire behavior results. LANDFIRE 2016 Remap 2.0.0 (LF Remap) data was used to generate a calibrated fuelscape for this region-wide assessment. Results were multiplied by burn probability and consider the likelihood of wildfire, or “expected” wildfire risk. Detailed documentation on the underlying models, data sources, and calculations can be found at https://pyrologix.com/wildfire-risk-across-the-eastern-region/

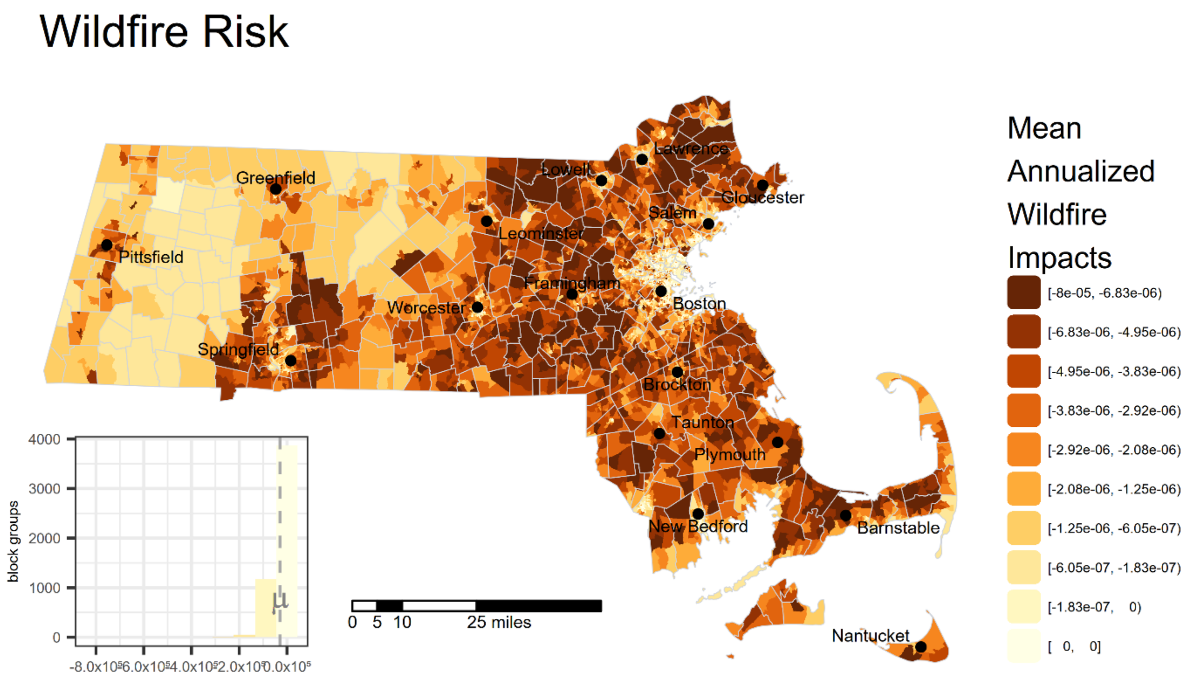
Data was downloaded from the Northeast-Midwest State Foresters Alliance Risk Explorer application at https://northeastwrap.uat.timmonsdev.com/Map/Public#whats-your-risk. Data acquired by county and provided as ESRI ArcGIS geopackages. Gridded data for Annualized Impacts to All HVRA was extracted from the geopackages as GeoTIFFs in ArcGIS Pro. These GeoTIFFs were resampled to a consistent 30-m resolution and mosaiced to a statewide raster using the terra package in R. Mean annualized impact values were extracted for each overlapping census block group.

Data years: 2019

Originating geographic scale of data: 30-meter pixels

Source: Northeast-Midwest State Foresters Alliance Risk Explorer. https://northeastwrap.uat.timmonsdev.com/Map/Public#whats-your-risk

Figure 22 - Map of Wildfire Risk index raw values



Flood Risk

Definition: Percentage of developed, populated areas where there is a one-percent chance or greater risk of flooding annually.

Description: Special Flood Hazard Areas (SFHAs) are defined by the Federal Emergency Management Agency (FEMA) as the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year.[57] The 1-percent annual chance flood is also referred to as the base flood or 100-year flood and is considered to be an area with a high risk of flooding.[58] The 100-year flood is significant in the Massachusetts Wetlands Protection Act (WPA) because it is used as a regulatory threshold to identify and protect floodplain areas that are critical to public safety, property protection, and ecosystem health. Under the WPA, areas that are subject to inundation by the 100-year flood (as defined by FEMA or calculated hydrologically) are classified as Bordering Land Subject to Flooding, which is a protected wetland resource area. Activities proposed in these areas are subject to wetlands permitting and review to ensure they do not cause adverse impacts like increased flooding, displacement of floodwaters, or loss of flood storage. Flood risk information in this dataset is for screening and cumulative burden scoring of census block groups. It should not be used for assessing localized flood risk.

Indicator type: *Climate Risks*

Rationale: Floods are the most common form of weather-related disaster in the US, and they are the second-leading cause of weather-related fatalities.[59] Floods can immediately impact health due to drowning, injuries, and hypothermia. Other health risks can be associated with the evacuation of patients, reduced access to health services, or the impact on basic services, including drinking water supply and quality. In the medium and long term, floods have been associated with infectious diseases (due to poor quality drinking water, lack of hygiene and sanitation, infected wounds, or insect bites), poisoning (due to chemicals in floodwater), and mental health issues (e.g., stress, anxiety, depression). Flood exposure can ultimately increase the risk of premature mortality.[60] Climate change increases the risk and severity of floods.

Method: FEMA National Flood Hazard Layer (NFHL) digital Flood Insurance Rate Maps (DFIRMs) were downloaded from the FEMA Flood Map Service Center

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[57] "Flood Zones | FEMA.Gov," July 8, 2020, https://www.fema.gov/about/glossary/flood-zones.
[58] "What Is My Flood Risk | The National Flood Insurance Program," accessed February 17, 2026, https://www.floodsmart.gov/flood-zones-and-maps/what-is-my-flood-risk.
[59] Chris Dolce, "America's Second-Biggest Weather Killer Is Flooding, And Texas Leads The Way | Weather.Com," July 7, 2025, https://weather.com/safety/floods/news/2025-07-07-flooding-united-states-second-biggest-weather-killer-texas.
[60] CDC, "Floods and Your Safety," Floods, September 30, 2024, https://www.cdc.gov/floods/about/index.html.

(https://msc.fema.gov/portal/advanceSearch). As of November 2025, finalized NFHL DFIRMs are not available for the northwest quadrant of Massachusetts – Berkshire County, Hampshire County, Franklin County, and portions of northern Worcester County. These areas were supplemented with preliminary NFHL DFIRMS from FEMA (https://hazards.fema.gov/femaportal/prelimdownload/). The latter cover Hampshire County, Franklin County, and northern Worcester County, but not Berkshire County. Flood coverage for Berkshire County was further supplemented with data from the FEMA Q3 Flood Zones from Paper FIRMs layer from MassGIS (https://www.mass.gov/info-details/massgis-data-fema-q3-flood-zones-from-paper-firms). These final, preliminary, and Q3 flood data covered all remaining areas except for the Town of Mount Washington in the southwest corner of the state. Mount Washington does not participate in the National Flood Insurance Program and does not have flood risk areas mapped by FEMA. To identify areas at risk of flooding in Mount Washington, we followed Massachusetts Wetlands Regulations approach at 310 CMR 10.57: in areas without FEMA data, "assume the area of flood risk is synonymous with the 200-foot Riverfront Area around rivers and the 100-foot buffer around Rivers in Densely Developed Areas." As it was determined that no areas of Mount Washington are Densely Developed, a 200-foot buffer was generated around all rivers and streams using the MassDEP Hydrography (1:25,000) from MassGIS (https://www.mass.gov/info-details/massgis-data-massdep-hydrography-125000). Areas falling within those 200-foot buffers were assumed to be at risk of flooding.

For final, preliminary, and Q3 NFHL data, areas within the 1% Annual Chance Flood Hazard were isolated. These included areas within zones "A", "AE", "AH", "AO", and "VE", or otherwise classified as being within a Special Flood Hazard Area (SFHA).

For more precise estimations of flood risk exposure, a dasymetric mapping approach was used to identify the developed and populated areas of census blocks at risk of flooding. Census blocks are the smallest geographic administrative unit at which population counts are reported by the US Census. As of 2020, the latest year for which block-level data is available, Massachusetts was divided into 88,207 populated census blocks. These census blocks had a median population count of 47 people (ranging from 1 to 3,258 people) and a median area of about 7 acres (ranging from less than 1 acre to 7,000 acres). To further refine the identification of that portion of a census block that is likely developed and occupied, the 2024 National Land Cover Database (NLCD) was acquired from the Multi-Resolution Land Characteristics (MRLC) consortium (https://www.mrlc.gov/). The NLCD is a raster or grid-based spatial dataset that represents the predominant state of the surface within the mapping year with respect to broad categories of natural and anthropogenic surface cover types, at 30-meter resolution. NLCD land areas classified as "Developed" (i.e., "Developed, High Intensity", "Developed, Medium Intensity", "Developed, Low Intensity", and "Developed, Open

Space") were spatially intersected with census blocks in order to retain only those portions of census block polygons classified as Developed. Finally, intersected polygons were further filtered to retain only those polygons that also contained building footprints with building footprint areas of at least 60 square feet as identified by the Building Structures (2-D) layer from MassGIS (https://www.mass.gov/info-details/massgis-data-building-structures-2-d).

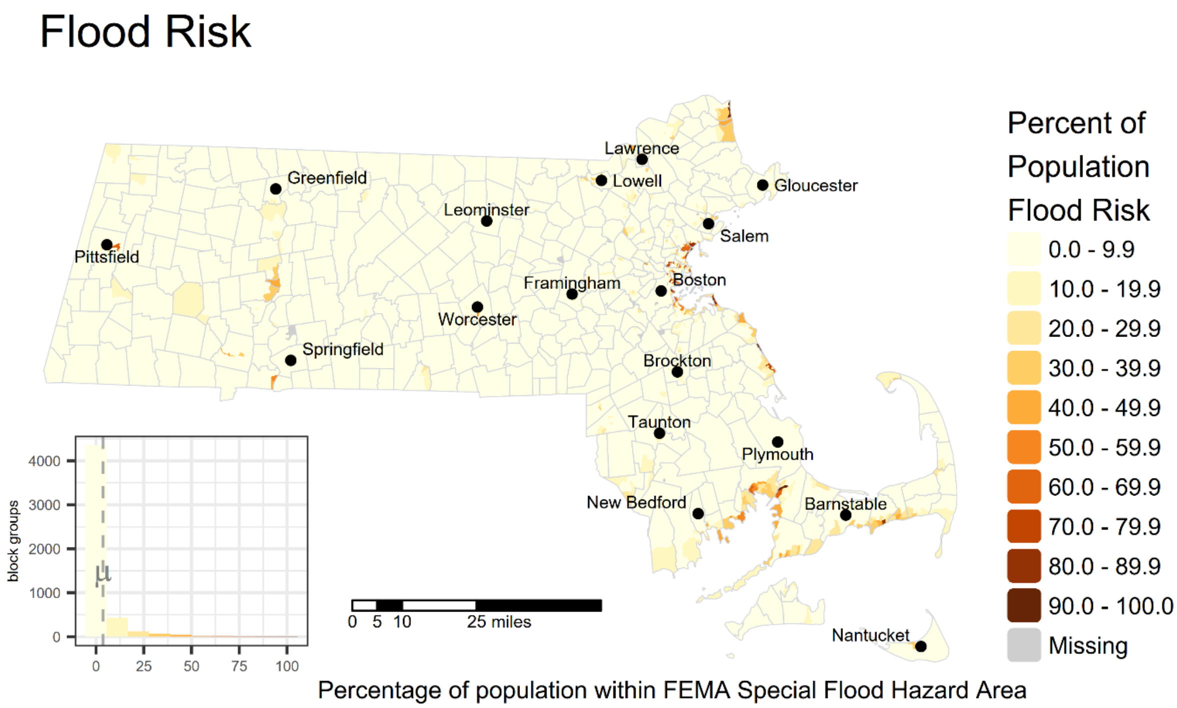
Census block populations were then allocated to those portions of the block identified as developed and containing building footprints. The proportion of developed block polygons that overlapped or intersected with flood risk areas was assumed to also represent the proportion of the respective block population exposed to flood risk. These at-risk block populations were aggregated and summed to their respective census block groups. Finally, the proportion of the census block group population at risk from flooding was calculated as the sum of exposed block-level populations divided by the total population of their respective block group.

Data years: Final FEMA National Flood Hazard DFIRMs 2025; Preliminary FEMA National Flood Hazard DFIRMs - Franklin County (5/22/2024), Hampshire County (8/27/2025), Worcester County (1/31/2025); FEMA Q3 Flood Zones from Paper FIRMs for Berkshire County from MassGIS 1997 - 2013; Building Structures (2-D) layer from MassGIS November 2024; MassDEP Hydrography (1:25,000) from MassGIS December 2019; National Land Cover Database from MRLC 2024; 2020 Decennial Census data on block-level and block group-level population counts from Census API

Originating geographic scale of data: census blocks; delineated flood polygons for NFHL and Q3 data at 1:12,000; delineated building footprints; delineated hydrography at 1:25,000; NLCD raster at 30-meter resolution

Source: FEMA National Flood Hazard Layer (NFHL) digital Flood Insurance Rate Maps (DFIRMs) from the FEMA Flood Map Service Center (https://msc.fema.gov/portal/advanceSearch); Preliminary FEMA National Flood Hazard Layer (NFHL) digital Flood Insurance Rate Maps (DFIRMs) from FEMA Map Service Center - Preliminary FEMA Map Products (https://hazards.fema.gov/femaportal/prelimdownload/); MassDEP Hydrography (1:25,000) from MassGIS (https://www.mass.gov/info-details/massgis-data-massdep-hydrography-125000); 2024 National Land Cover Database (NLCD) from the Multi-Resolution Land Characteristics (MRLC) consortium (https://www.mrlc.gov/); Building Structures (2-D) layer from MassGIS (https://www.mass.gov/info-details/massgis-data-building-structures-2-d); Census 2020 decennial population counts at block and block group levels via Census API

Figure 23 - Map of Flood Risk raw values



Extreme Heat Days

Definition: Number of unhealthy heat events over the last 30 years (1996 - 2025) in which air temperatures rose to 85F or higher for 3 or more days in a row.

Description: Extremely hot days can cause health risks due to heat exhaustion and dehydration. Extremely hot days can also cause electrical outages, which can hurt the health of people who use machines for healthcare purposes. Climate change increases the number and severity of extreme heat days. This indicator describes the number of unhealthy heat events between 1996 and 2025. Unhealthy heat events are defined by the Massachusetts Bureau of Climate and Environmental Health as periods in which temperatures of 85°F or more persist for 3 or more days. Analyses by the Bureau show that when temperature rises to 85°F or more for three days in a row, there is a significant increase in emergency room visits and heat-related illnesses.[61] The Unhealthy Heat Threshold identifies predictably significant health impacts and was consistent across summers. Temperatures of 85°F for 3 or more days in a row will trigger unhealthy heat alert notifications for healthcare professionals, local governments and other community and state organizations.

Indicator type: *Climate Risks*

Rationale: Heat-related illnesses occur when people are exposed to an abnormal or prolonged amount of heat without relief or adequate fluid intake.[62] Heat-related illnesses include heat stroke, exhaustion, cramps, rash, and sunburn. Heat-related illnesses can also increase the risk of premature mortality. Infants, children, older adults, and those living with medical conditions are more susceptible to developing health-related issues. Moreover, outdoor workers, athletes, and those without access to shelter, air conditioning, and drinking water are also more vulnerable to extreme heat days.

Method: Data on daily maximum air temperatures for the period 1996 through 2025 was downloaded from the Oregon State University PRISM Group via the "prism" package in R. Datasets are provided as single-layer grids covering the coterminous US for each day at 800-meter resolution. These grids were stacked and a count of runs of days with temperatures equal to or greater than 85°F for 3 or more days were summed, providing a total count of the number of runs of 3 days or more at or above 85°F per pixel or grid cell. Each census block group in Massachusetts was assigned the average count of overlapping grid cells.

Data years: 1996 – 2025

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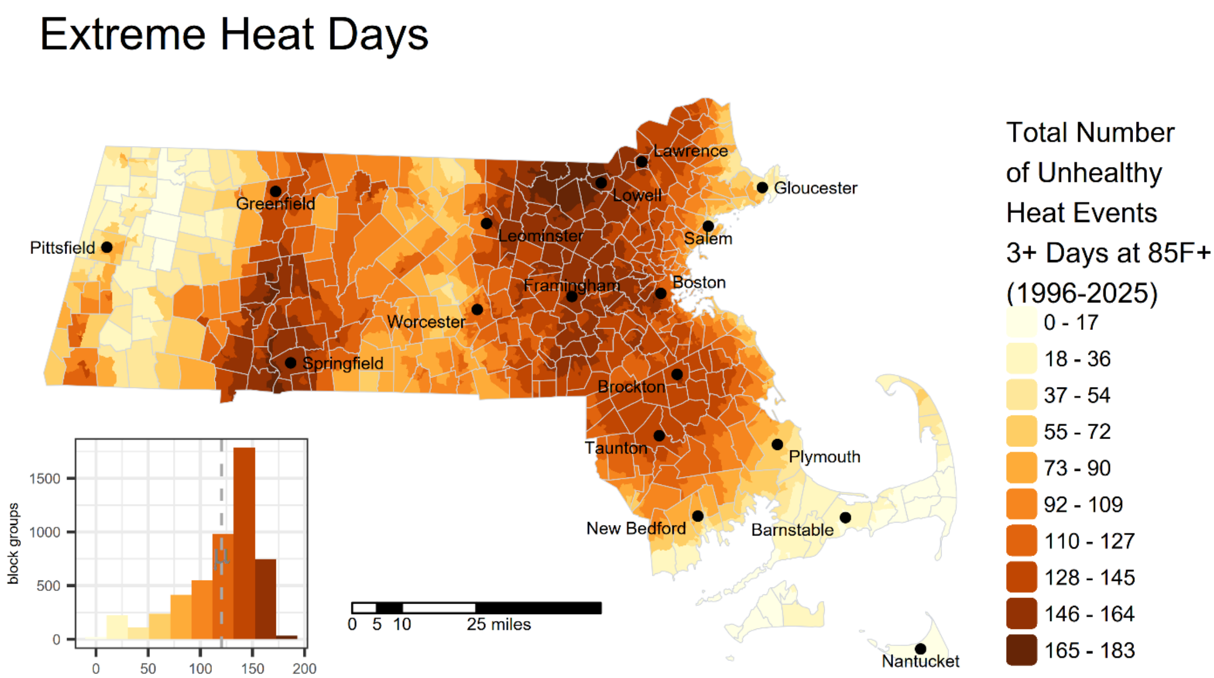
[61] Massachusetts Bureau of Climate and Environmental Health. "Massachusetts Unhealthy Heat Forecast." Accessed January 12, 2026. https://www.mass.gov/info-details/massachusetts-unhealthy-heat-forecast.
[62] Kristie L. Ebi et al., "Hot Weather and Heat Extremes: Health Risks," *The Lancet* 398, no. 10301 (2021): 698–708, https://doi.org/10.1016/S0140-6736(21)01208-3.

Originating geographic scale of data: 800m pixels or grid cells

Source: PRISM Group, Oregon State University, https://prism.oregonstate.edu, data created April 1996 through October 2025, accessed 29 Dec 2025.

Figure 24 - Map of Extreme Heat Days raw values



Population Characteristics - Sensitive Populations

Pediatric Asthma

Definition: Population-weighted average asthma prevalence (percentage of K-8 enrollment). The rate in Massachusetts is 10.5%.

Description: Asthma prevalence in schools is defined as the percentage of enrolled students reported by school nurses to have asthma during a school year. Schools are public, charter, and private. School-based asthma data are reported annually by school nurses through the Massachusetts Department of Public Health Pediatric Asthma and Diabetes Survey for students in grades K-8 who have ever been diagnosed with asthma. Average prevalence for each census block group was calculated based on the average prevalence of all schools associated with that block group, weighted by school enrollment.

Indicator type: *Sensitive Populations*

Rationale: Asthma is an illness that affects the respiratory tract and airways that carry oxygen into and out of the lungs. During an asthma attack, these airways constrict, resulting in wheezing and difficulty breathing. Asthma can affect people of all ages. However, it often starts in childhood and is more common in children than adults. Asthma is a common chronic disease that continues to increase in prevalence. It is the most common chronic disease in children. The Commonwealth of Massachusetts has an elevated rate of asthma compared to the national prevalence rate.[63] Causes of asthma are unknown. However, episodes of asthma (asthma attacks) can be triggered by certain environmental pollutants such as air pollution, mold, pets/pet dander, and dust mites. A number of studies have reported links between exposure to air pollution and asthma. Several criteria air pollutants are known to exacerbate asthma symptoms and contribute to asthma development. In addition, climate change may affect air quality and worsen asthma in several ways. Climate-driven changes in weather can increase certain criteria air pollutants like ozone and particulate matter, as well as other triggers such as pollen, mold, dust mites, and bacteria, all of which may exacerbate asthma. Climate change also leads to more frequent wildfires, which worsen respiratory illnesses including asthma. Reducing exposure to these pollutants can help prevent symptoms. Asthma impacts certain groups more than others, including children, older adults, people of color, and those of lower socioeconomic status. These disparate impacts may be due to environmental factors related to socioeconomic status, like housing conditions or proximity to sources of pollution. Children of color have a higher prevalence of

[63] MA Department of Public Health, "Asthma Overview," accessed July 22, 2025, https://matracking.ehs.state.ma.us/Health-Data/Asthma/index.html.

asthma and asthma-related emergencies. Children with asthma seem to be impacted by particle pollution more so than adults with asthma.[64]

Method: MDPH calculated the school rates for asthma prevalence and provided these to MassDEP with values per school. Each school was associated with census block groups using the following steps:

1. Data Source: The public schools dataset is from MassGIS - Massachusetts Schools (Pre-K through High School), dated December 2024.
2. Initial Coverage: School districts, towns, and ZIP codes were assigned to block groups based on centroid location to ensure full statewide coverage.
3. District-Level Assignment: If a school is the only one of its type in a district, all block groups in that district are assigned to it.
4. Town-Level Assignment: For unassigned cases, if only one school of that type exists in a town, its block groups are assigned to that school.
5. ZIP Code-Level Assignment: If still unassigned, block groups are matched to a school by ZIP code if only one school of that type exists in the ZIP.
6. 0.5-Mile Buffer: Remaining unassigned block groups are matched to schools within a 0.5-mile buffer, limited to schools in the same district.
7. Fallback Matching: For all types except Other/Unknown, any remaining block groups are assigned to the *nearest* school of the same type within the same district.

The pediatric asthma data is based on the original CIA dataset from MDPH (2017–2024).
Please note that 15 block groups remain unmatched due to suppressed or missing data (e.g., missing enrollment counts or closed schools with outdated codes).

Average prevalence for each census block group was calculated based on the average prevalence of all schools associated with each block group, weighted by school enrollment. Schools missing asthma or enrollment data were excluded.

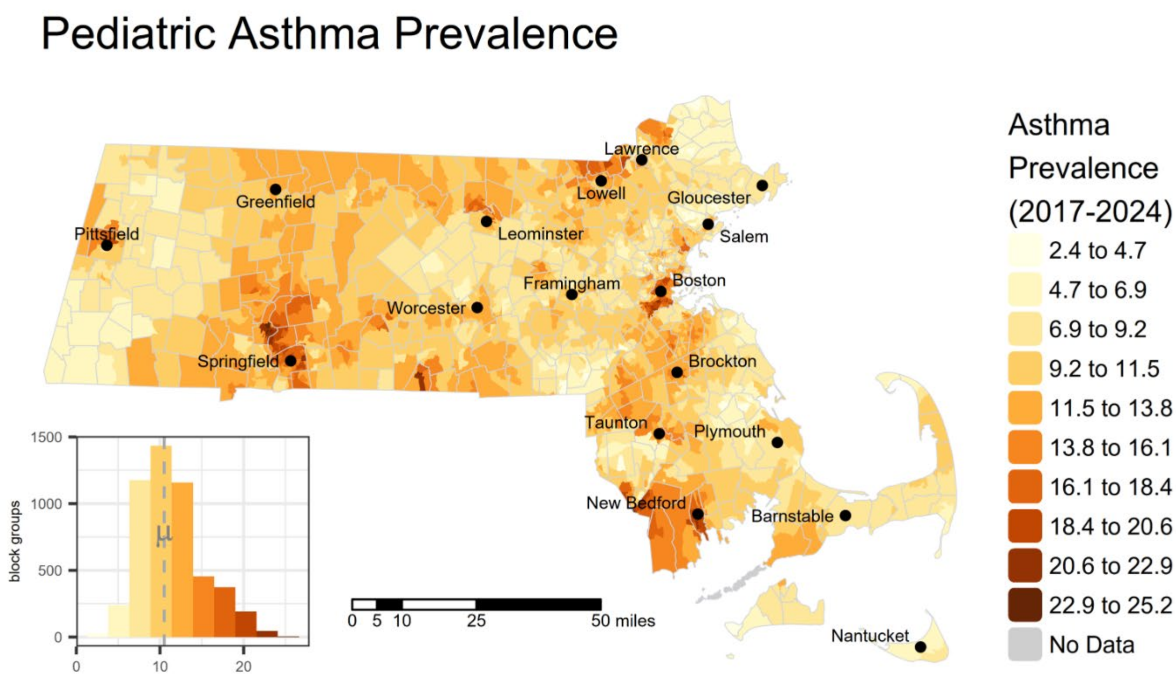
Data years: 2017 – 2024 (updated December 2025)

Originating geographic scale of data: school point locations

[64] US EPA, *Indicators of Environmental Health Disparities: Childhood Asthma Prevalence*, EPA 231R24003 (US Environmental Protection Agency, 2024), https://www.epa.gov/system/files/documents/2024-12/ej-indicators-asthma.pdf.

Source: MassDEP Cumulative Impact Analysis in Air Quality Permitting at https://www.mass.gov/info-details/cumulative-impact-analysis-in-air-quality-permitting#cia-guidance-and-tools-

Figure 25 - Map of Pediatric Asthma Prevalence raw values



Elevated Blood Lead Levels in Children

Definition: 5-year average prevalence of elevated (≥5 µg/dL estimated confirmed) childhood blood lead levels in children (ages 9-47 months). The prevalence in Massachusetts is 18.4 per 1,000 children screened.

Description: Exposure to lead through paint is the most significant source of lead exposure for children. Lead is a toxic heavy metal and occurs naturally in the environment. However, most of the high levels of lead found in our environment result from human activities. Historically, lead was used as an additive in gasoline and as a primary ingredient in house paint. Lead levels in the United States have declined over the past five decades due to various regulations. However, lead persists in older buildings containing lead paint, as well as old plumbing and contaminated soil. Young children absorb lead more easily than adults. The Massachusetts Lead Poisoning Prevention and Control Act is a state law that requires all children to be screened each year for lead poisoning through age three. Children living in high-risk communities must be screened each year through age four. All children must show proof of screening at least once to enter daycare, pre-kindergarten programs, and kindergarten.

Indicator type: *Sensitive Populations*

Rationale: Young children are especially susceptible to the effects of lead exposure and can suffer profound and permanent adverse health effects, particularly in the brain and nervous system.[65] This increased susceptibility is due to their unique exposure pathways (e.g., dust-to-hand-to-mouth), developing brains, and differences in the absorption of ingested lead.[66] Lead in the body can: hurt the brain, kidneys, and nervous system, slow down growth and development, make it hard to learn, damage hearing and speech, and cause behavior problems. There are no known safe levels of lead exposure, and levels that were previously considered safe are now known to cause subtle, chronic health effects. In October 2021, the Centers for Disease Control and Prevention (CDC) lowered the blood lead reference value (BLRV) from 5 micrograms per deciliter (µg/dL) to 3.5 µg/dL.

Method: All census block groups received the prevalence value for the census tract in which they are located.

Data years: 2017 – 2021 (updated December 2025)

Originating geographic scale of data: census tracts

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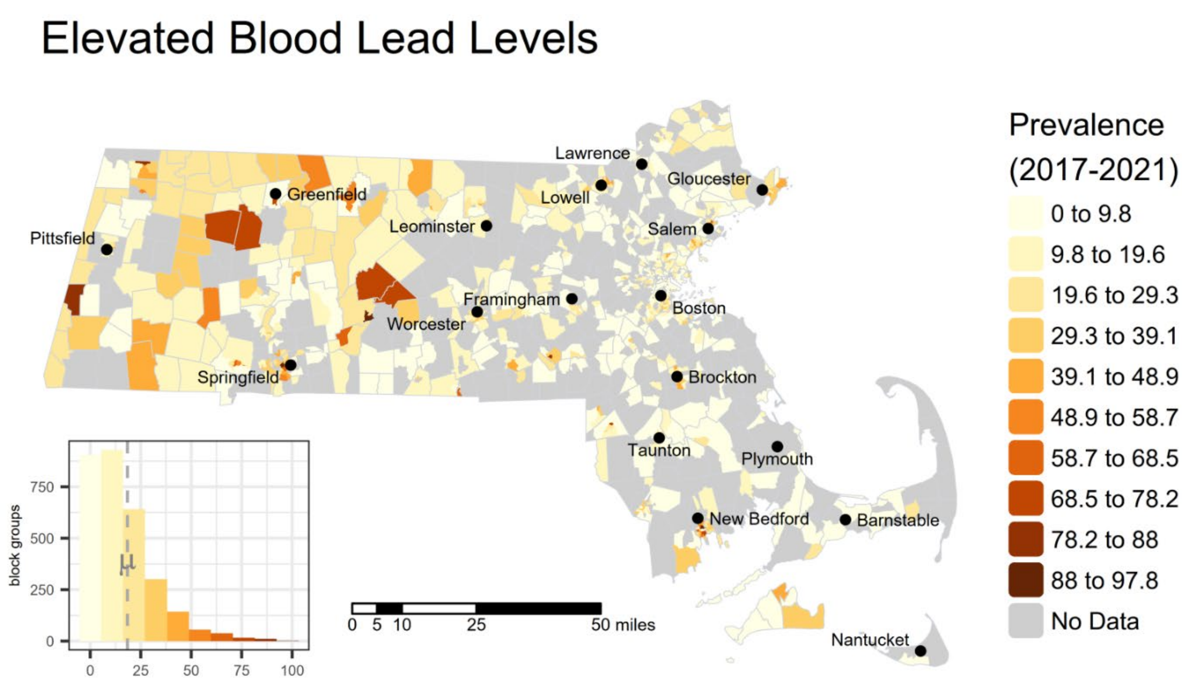
[65] World Health Organization, “Lead Poisoning,” accessed July 22, 2025, https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health.

[66] CDC, “About Childhood Lead Poisoning Prevention,” Childhood Lead Poisoning Prevention, March 13, 2025, https://www.cdc.gov/lead-prevention/about/index.html.

Source: Massachusetts Environmental Public Health Tracking via MassDEP Cumulative Impact Analysis in Air Quality Permitting at https://www.mass.gov/info-details/cumulative-impact-analysis-in-air-quality-permitting#cia-guidance-and-tools-

Figure 26 - Map of Elevated Blood Lead Levels raw values



Low Birth Weight Infants

Definition: 5-Year annual average low birth weight (less than 2,500 grams) per 100 full-term births. The state rate is 2.2 per 100 full-term births.

Description: Birth weight, which is impacted by the length of gestation and fetal growth, is considered low when infants weigh less than 2,500 grams (5lbs and 8 ounces). Preterm birth and low birth weight are associated with a range of health issues for children, including breathing problems, feeding difficulties, developmental delay, hearing and vision problems, and more.

Indicator type: *Sensitive Populations*

Rationale: Compared to normal birth weight infants, low birth weight infants may be more at risk for illness through the first six days of life, infections, and long-term impairment, such as delayed motor and social development or learning disabilities. Preterm birth and low birth weight are associated with a range of health issues for children, including breathing problems, feeding difficulties, developmental delay, hearing and vision problems, and more.[67] There are many potential causes for adverse birth outcomes, including maternal health conditions and lifestyle factors.[68] The role that exposure to environmental contaminants plays in adverse birth outcomes is not yet fully understood, particularly in the potential causation of preterm birth and low birth weight.[69] Various exposures have been implicated as risk factors for full-term low birth weight, including maternal exposure to lead and exposure to toxic substances in air, water or food.[70] Research suggests that exposure to PM2.5, carbon monoxide, and nitrogen oxides might contribute to preterm birth and low birth weight.[71] Exposure to lead is also known to cause reduced fetal growth and may cause preterm birth.[72] Preterm and low

[67] CDC, "Preterm Birth," Maternal Infant Health, February 24, 2025, https://www.cdc.gov/maternal-infant-health/preterm-birth/index.html.

[68] CDC, "Reproductive & Birth Outcomes," Environmental Public Health Tracking, May 29, 2024, https://www.cdc.gov/environmental-health-tracking/php/data-research/reproductive-birth-outcomes.html.

[69] US EPA, *Adverse Birth Outcomes* (US Environmental Protection Agency, 2015), https://www.epa.gov/sites/default/files/2015-06/documents/health-adverse-birth-outcomes.pdf.

[70] NCHS, *National Vital Statistics System Improvements Fact Sheet* (National Center for Health Statistics, 2019), https://www.cdc.gov/nchs/data/factsheets/factsheet-nvss-improvements-H.pdf.

[71] US EPA, "Integrated Science Assessment (ISA) for Particulate Matter," Reports and Assessments, US EPA, November 20, 2019, https://assessments.epa.gov/risk/document/&deid%3D347534; US EPA, "Integrated Science Assessment (ISA) for Oxides of Nitrogen," Reports and Assessments, US EPA, 2016, https://ordspub.epa.gov/ords/eims/eimscomm.getfile?p_download_id=526855; US EPA, "Integrated Science Assessment (ISA) for Carbon Monoxide (Final Report, Jan 2010)," Reports and Assessments, US EPA, January 13, 2010, https://assessments.epa.gov/isa/document/&deid%3D218686.

[72] US EPA, "Integrated Science Assessment (ISA) for Lead (Final Report)," Reports and Assessments, US EPA, November 20, 2023, https://assessments.epa.gov/isa/document/&deid%3D359536.

birth weight infants have a higher risk of health issues and mortality from childhood to adulthood.[73]

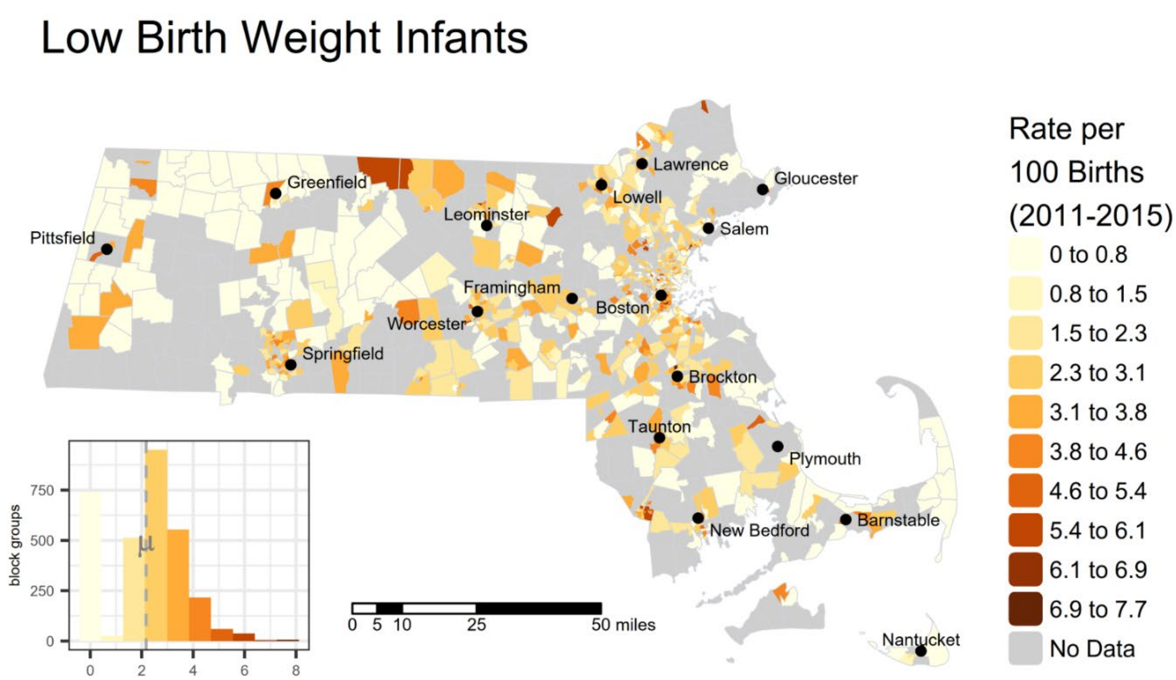
Method: All census block groups received the prevalence value for the census tract in which they are located. Some block groups have no data due to very small numbers that are suppressed by MDPH to protect privacy.

Data years: 2011-2015 (updated December 2025)

Originating geographic scale of data: census tract

Source: Massachusetts Department of Public Health Birth Outcomes Data of Massachusetts Residents at https://www.mass.gov/info-details/birth-outcomes-data-of-massachusetts-residents via MassDEP Cumulative Impact Analysis in Air Quality Permitting at https://www.mass.gov/info-details/cumulative-impact-analysis-in-air-quality-permitting#cia-guidance-and-tools-

Figure 27 - Map of Low Birth Weight Infants raw values



[73] US EPA, *Adverse Birth Outcomes*.

Premature Mortality (PM)

Definition: Age-adjusted premature mortality rate (per 100,000). The rate in Massachusetts is 292.8 per 100,000 residents.

Description: Premature mortality tracks unfulfilled life expectancy and is based on deaths prior to age 75. Premature mortality includes unintentional injuries such as motor vehicle-related deaths, poisonings, falls, fires, and drownings that were not intended to occur. Deaths are for all age groups.

Indicator type: *Sensitive Populations*

Rationale: Premature mortality is a powerful marker of multiple diseases and the health status in a community. Life expectancy can be improved in communities through public health and clinical care practices. Reduced life expectancy has been associated with environmental risk factors, such as air, water, and soil pollution, noise, proximity to traffic and contaminated sites, and climate risks (droughts, floods, wildfires, and extreme heat days), among others.

Method: Massachusetts Department of Public Health (MDPH) provided an age-adjusted premature mortality rate (PMR per 100,000) by census tract.[74] All census block groups received the mortality rate for the census tract in which they are located.

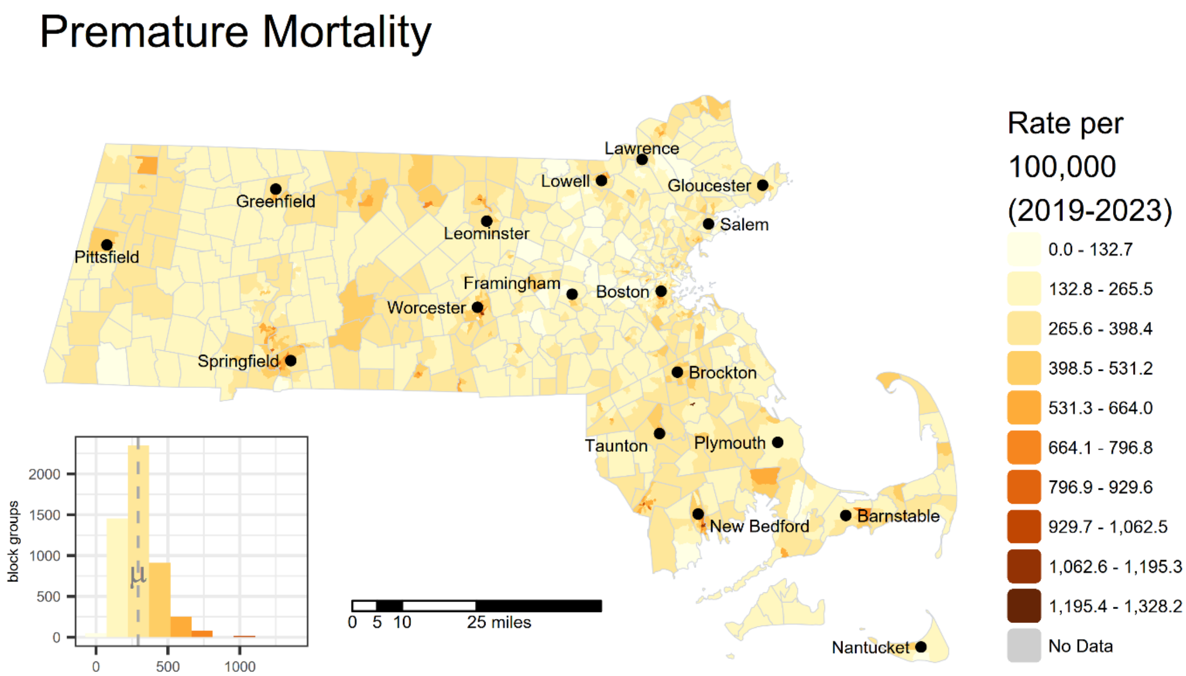
Data years: 2019 – 2023 (updated December 2025)

Originating geographic scale of data: census tracts

Source: Massachusetts Department of Public Health Death Data Registry of Vital Records and Statistics acquired via MassDEP Cumulative Impact Analysis in Air Quality Permitting at https://www.mass.gov/info-details/cumulative-impact-analysis-in-air-quality-permitting#cia-guidance-and-tools-

[74] "Deaths of Massachusetts Residents | Mass.Gov," accessed February 17, 2026, https://www.mass.gov/info-details/deaths-of-massachusetts-residents.

Figure 28 - Map of Premature Mortality raw values



Adult High Blood Pressure

Definition: Prevalence of high blood pressure among adults. The prevalence in Massachusetts is 29.9%.

Description: High blood pressure, also called hypertension, is blood pressure that is higher than normal. Higher blood pressure levels put individuals at greater risk for other health problems, such as heart disease, heart attack, and stroke.

Indicator type: *Sensitive Populations*

Rationale: Hypertension, a type of cardiovascular disease (CVD) that leads to a prolonged increase in blood pressure, is a major risk factor for other CVD conditions like coronary heart disease and stroke. Risk factors for hypertension include obesity, physical inactivity, and high sodium consumption.[75] Traditional risk factors for CVD, like male sex, older age, increased blood pressure, high cholesterol, and smoking, account for about 50 percent of cardiac events. There are also known environmental exposures that act independently or in conjunction with established risk factors to impact CVD and hypertension.[76] Lead exposure can lead to both cardiovascular effects and cardiovascular-related mortality. There is consistent evidence to show that lead exposure increases blood pressure in adults, hypertension, and cardiovascular mortality, with more limited information on lead relating to changes in heart rate variability and the development of atherosclerosis.[77] Air pollution exposure has also been found to contribute to the development of CVD and hypertension and exacerbate existing CVD conditions. Evidence is particularly strong for short-term and long-term exposures to fine particulate matter, or particulate matter with a diameter of less than 2.5 μm.[78] In addition, the effects of climate change may cause or worsen certain illnesses and health conditions. Climate-related changes to weather and heat can worsen air quality by impacting ozone and particulate matter concentrations, wildfires, and allergens. The effects of climate change on air quality pose human health risks, including heart disease and stroke. People with conditions such as hypertension are particularly vulnerable to the adverse effects of climate change on outdoor air quality. Certain populations remain at a disproportionate risk for exposure and negative health outcomes. Those at increased risk of exposure to particle pollution include non-white and low-income populations, as well as those who live or work in urban and industrial areas. Elderly and other high-risk populations are also heavily impacted. Studies have

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[75] CDC, "About High Blood Pressure," High Blood Pressure, January 28, 2025, https://www.cdc.gov/high-blood-pressure/about/index.html.
[76] US EPA, *Indicators of Environmental Health Disparities Age-Adjusted Hypertension Technical Documentation* (US Environmental Protection Agency, 2024).
[77] US EPA, "Integrated Science Assessment (ISA) for Lead (Final Report)."
[78] US EPA, "Particle Pollution and Cardiovascular Effects," Collections and Lists, September 15, 2014, https://www.epa.gov/pmcourse/particle-pollution-and-cardiovascular-effects.

shown exposure to ambient airborne particulate matter could be associated with increased hospitalizations and mortality among older individuals, largely due to cardiopulmonary and cardiovascular disease.[79]

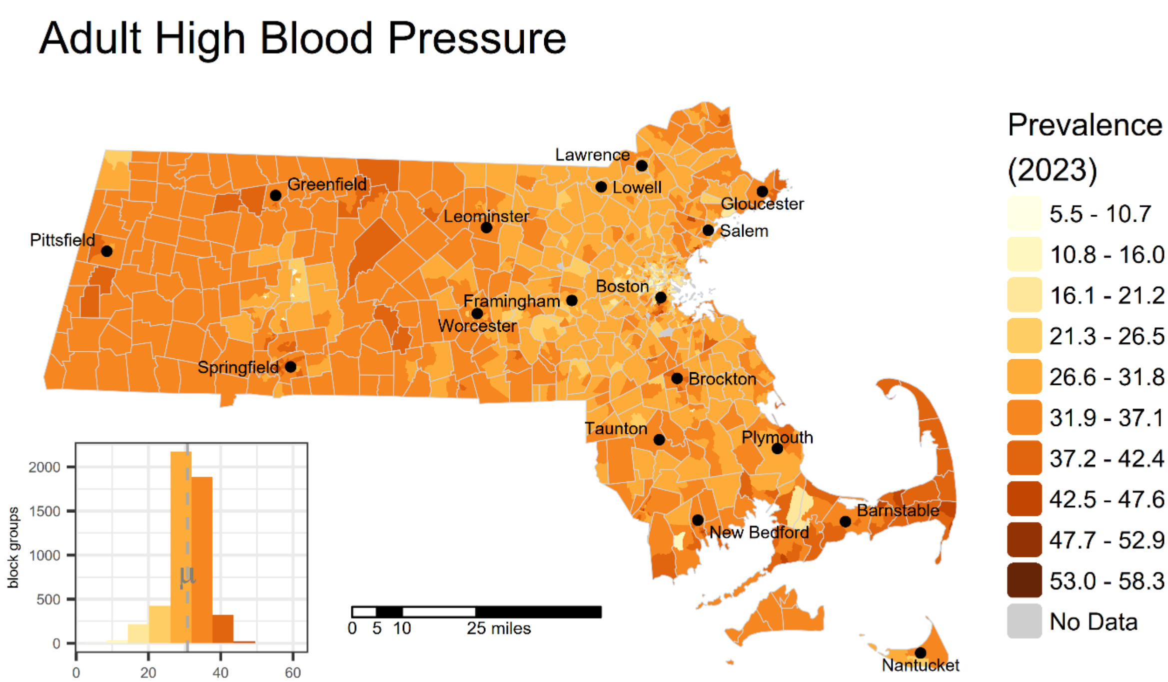
Method: Data provided a census tract level. All census block groups received the prevalence value for the census tract in which they are located.

Data years: 2023 (last updated December 12, 2025)

Originating geographic scale of data: census tracts

Source: CDC PLACES Health Outcomes at https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh/about_data

Figure 29 - Map of Adult High Blood Pressure raw values



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79 US EPA, *Indicators of Environmental Health Disparities Age-Adjusted Hypertension Technical Documentation*.

Coronary Heart Disease

Definition: Prevalence of coronary heart disease among adults. The prevalence in Massachusetts is 4.6%.

Description: Coronary heart disease (also called ischemic heart disease) is caused by plaque buildup on the arteries. These blockages can limit the amount blood and oxygen the heart receives causing chest pain or angina. Coronary heart disease may present as an acute myocardial infarction which happens when the blood flow to a part of the heart is blocked by plaque.

Indicator type: *Sensitive Populations*

Rationale: Coronary artery disease (CAD) is the most common type of heart disease in the United States. Overweight, physical inactivity, unhealthy eating, and smoking tobacco are behavioral risk factors for CAD. There is a growing body of evidence showing that physicochemical factors in the environment contribute significantly to the cardiovascular diseases such as coronary heart disease. Urbanization is often associated with accumulation and intensification of these stressors.[80] Globally, some research concludes that environmental causes may be a larger cardiovascular mortality risk factor than those attributable to metabolic, tobacco use, and behavioral risk factors.[81]

Method: Data provided a census tract level. All census block groups received the prevalence value for the census tract in which they are located.

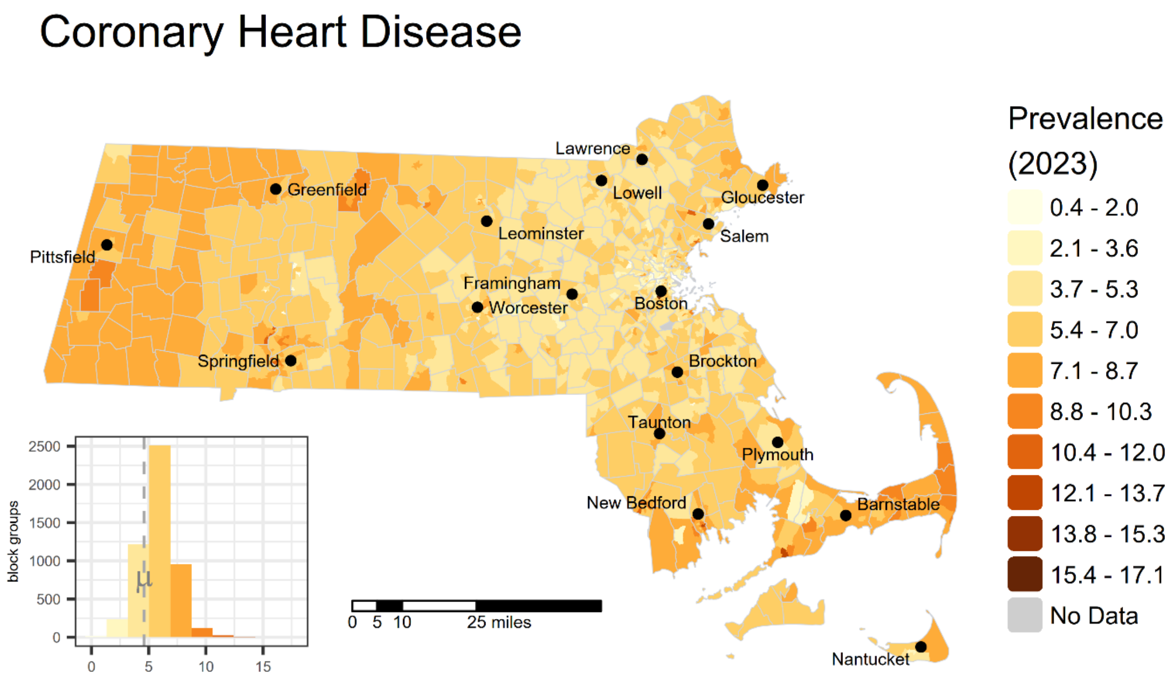
Data years: 2023 (last updated December 12, 2025)

Originating geographic scale of data: census tracts

Source: CDC PLACES Health Outcomes at https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh/about_data

[80] Thomas Münzel et al., "Environmental Risk Factors and Cardiovascular Diseases: A Comprehensive Expert Review," *Cardiovascular Research* 118, no. 14 (2022): 2880–902, https://doi.org/10.1093/cvr/cvab316.
[81] Shilpa S. Shetty et al., "Environmental Pollutants and Their Effects on Human Health," *Heliyon* 9, no. 9 (2023), https://doi.org/10.1016/j.heliyon.2023.e19496.

Figure 30 - Map of Coronary Heart Disease raw values



Chronic Obstructive Pulmonary Disease (COPD)

Definition: Prevalence of chronic obstructive pulmonary disease among adults. The prevalence in Massachusetts is 5.8%.

Description: Chronic Obstructive Pulmonary Disease, or COPD, refers to a group of diseases including emphysema and chronic bronchitis, that block airflow and cause breathing-related problems.

Indicator type: *Sensitive Populations*

Rationale: COPD is a leading cause of death in the US and in Massachusetts. The main cause of COPD is smoking, but nonsmokers can also get COPD. Approximately 85-90% of COPD diagnoses are attributed to cigarette smoking. Occupation exposures may account for another 15% of COPD diagnoses. A history of asthma may increase the risk of developing COPD. Long-term exposure to air pollution, secondhand smoke, dust, fumes and chemicals (which are often work-related) can cause COPD.[82] Although the primary cause of COPD is smoking, an increasing number of studies have reported associations between indoor and outdoor air pollution exposures and COPD, suggesting that environmental exposure could be driving a large percentage of COPD cases.

Method: Data provided a census tract level. All census block groups received the prevalence value for the census tract in which they are located.

Data years: 2023 (last updated December 12, 2025)

Originating geographic scale of data: census tracts

Source: CDC PLACES Health Outcomes at https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh/about_data

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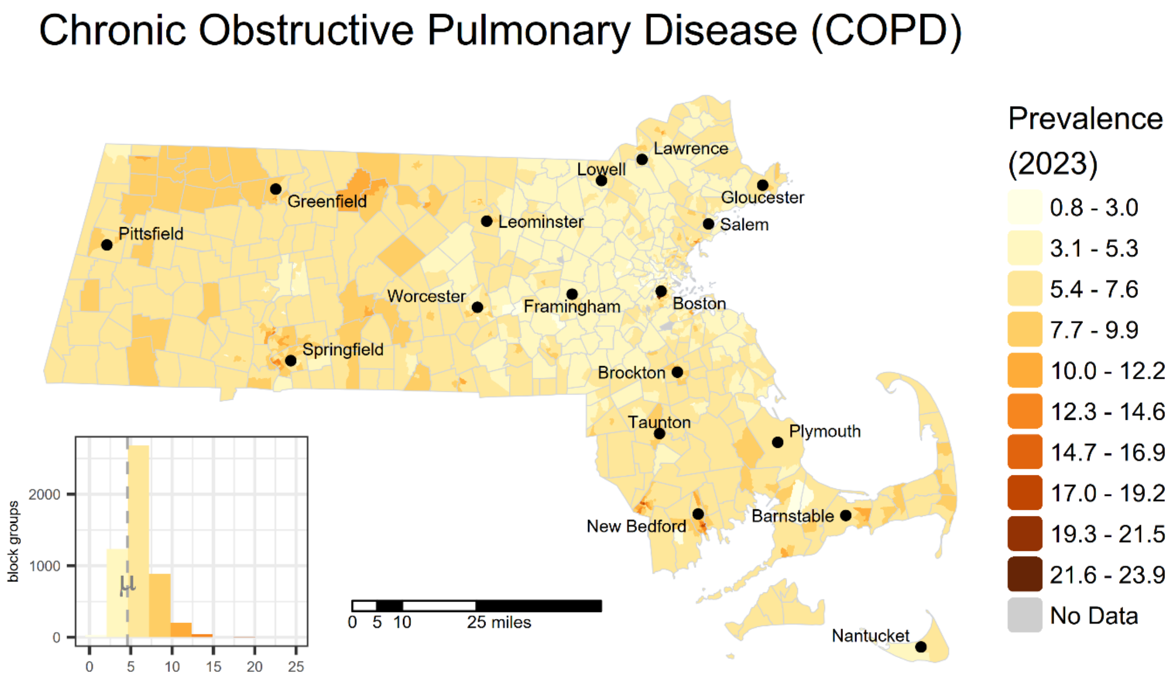
[82] Massachusetts Environmental Public Health Tracking, "Chronic Obstructive Pulmonary Disease (COPD)," accessed July 23, 2025, https://matracking.ehs.state.ma.us/Health-Data/copd.html.

Figure 31 - Map of Chronic Obstructive Pulmonary Disease (COPD) raw values



Adult Cancer

Definition: Prevalence of cancer (non-skin) or melanoma among adults. The prevalence in Massachusetts is 8.3%.

Description: Cancer is a group of similar diseases in which some of the body's cells grow uncontrollably and spread to other parts of the body. There are many types of cancer that affect different parts of the body. At least two-thirds of cancer cases are caused by external factors. These factors include tobacco and alcohol use, diet, sun exposure, and certain infections. Exposure to certain chemical pollutants or radiation is also a risk factor. This indicator represents how many people are living with cancer.

Indicator type: *Sensitive Populations*

Rationale: Cancer is the leading cause of death in Massachusetts.[83] Cancer is a group of chronic diseases that can start in any organ or tissue of the human body. Cancers are also called malignant neoplasms or tumors. Cancer develops when abnormal cells grow uncontrollably and go beyond their usual boundaries to invade adjoining body parts or spread to other organs. Lung, colorectal, and breast cancers are common types of cancers. Cancer can happen in all age groups. Among 30-50% of all cancers can be prevented.[84] Multiple environmental risk factors have been associated with cancer development, such as air, soil, and water pollution, metals, pesticides, sun exposure, chemicals, and radon, among others.[85] In those patients diagnosed with cancer, environmental pollutants can worsen the prognosis.

Method: Data provided at census tract level. All census block groups received the prevalence value for the census tract in which they are located.

Data years: 2023 (last updated December 12, 2025)

Originating geographic scale of data: census tracts

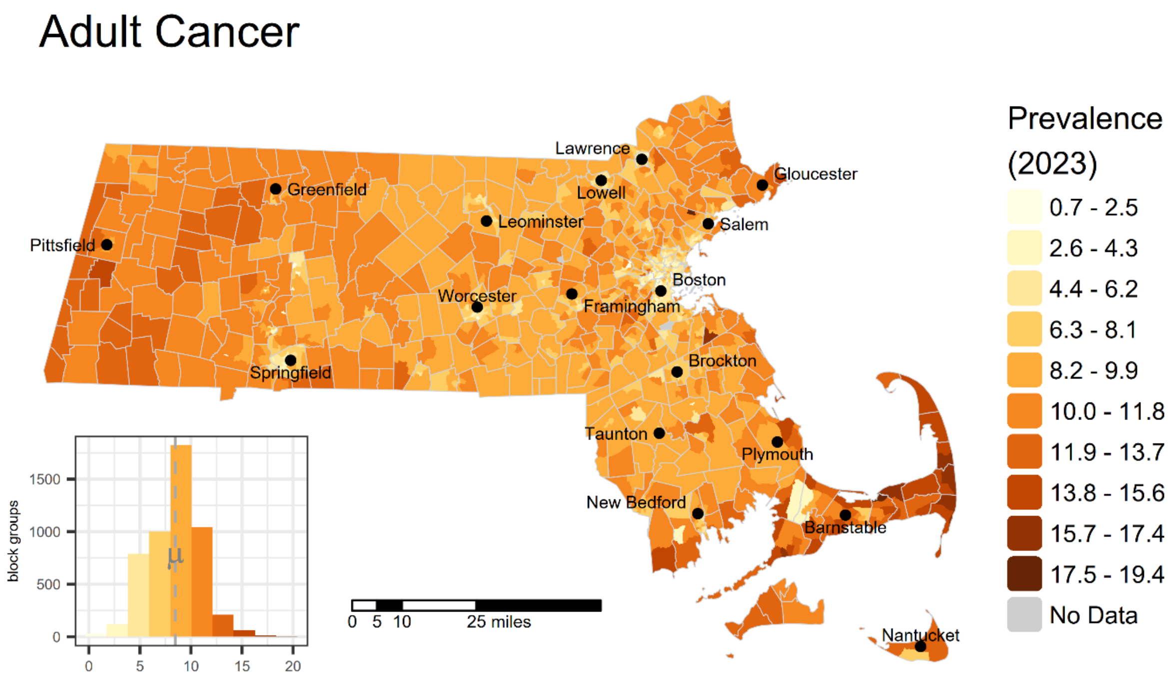
Source: CDC PLACES Health Outcomes at https://data.cdc.gov/500-Cities-Places/PLACES-Local-Data-for-Better-Health-Census-Tract-D/cwsq-ngmh/about_data

[83] Massachusetts Executive Office of Health and Human Services, "Mortality | Mass.Gov," accessed July 23, 2025, https://www.mass.gov/info-details/mortality.

[84] World Health Organization, "Preventing Cancer," accessed July 23, 2025, https://www.who.int/activities/preventing-cancer.

[85] National Cancer Institute, "Cancer-Causing Substances in the Environment - NCI," cgvArticle, March 18, 2015, nciglobal,ncienterprise, https://www.cancer.gov/about-cancer/causes-prevention/risk/substances.

Figure 32 - Map of Adult Cancer raw values



Population Characteristics - Socioeconomic Factors

Adults Without a High School Diploma

Definition: Percent of people age 25 or older whose education is less than a high school diploma.

Description: How much education a person has is associated with wealth, health, length of life, and exposure to pollution. People with less education are more likely to be affected by pollution because of where they live or work.

Indicator type: *Socioeconomic Factors*

Rationale: Educational attainment is an important independent predictor of health.[86] Individuals with lower education in the US have a lower life expectancy,[87] are more likely to be obese,[88] and are more likely to experience psychiatric disorders compared to individuals with higher education.[89] Education is often inversely related to the degree of exposure to indoor and outdoor pollution. Several studies have associated educational attainment with susceptibility to the health impacts of environmental pollutants. For example, individuals without a high school education appear to be at higher risk of mortality associated with particulate air pollution than those with a high school education.[90] There is also evidence that the effects of air and traffic-related pollution on respiratory illness, including childhood asthma, are more severe in communities with lower levels of education.[91] In studies evaluating air pollution related

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[86] David M. Cutler and Adriana Lleras-Muney, *Education and Health: Evaluating Theories and Evidence*, no. w12352 (National Bureau of Economic Research, 2006), https://doi.org/10.3386/w12352; Anna Zajacova and Elizabeth M. Lawrence, "The Relationship Between Education and Health: Reducing Disparities Through a Contextual Approach," *Annual Review of Public Health* 39, no. Volume 39, 2018 (2018): 273–89, https://doi.org/10.1146/annurev-publhealth-031816-044628.

[87] Jennifer Karas Montez and Erin M. Bisesti, "Widening Educational Disparities in Health and Longevity," *Annual Review of Sociology* 50, no. Volume 50, 2024 (2024): 547–64, https://doi.org/10.1146/annurev-soc-071723-080605.

[88] A. K. Cohen et al., "Educational Attainment and Obesity: A Systematic Review," *Obesity Reviews* 14, no. 12 (2013): 989–1005, https://doi.org/10.1111/obr.12062.

[89] Julie Erickson et al., "Educational Attainment as a Protective Factor for Psychiatric Disorders: Findings from a Nationally Representative Longitudinal Study," *Depression and Anxiety* 33, no. 11 (2016): 1013–22, https://doi.org/10.1002/da.22515.

[90] C. Arden Pope et al., "Mortality Risk and Fine Particulate Air Pollution in a Large, Representative Cohort of U.S. Adults," *Environmental Health Perspectives* 127, no. 7 (2019): 077007, https://doi.org/10.1289/EHP4438.

[91] Sabit Cakmak et al., "Respiratory Health Effects of Air Pollution Gases: Modification by Education and Income," *Archives of Environmental & Occupational Health* 61, no. 1 (2006): 5–10, https://doi.org/10.3200/AEOH.61.1.5-10; Matthew J. Neidell, "Air Pollution, Health, and Socio-Economic Status: The Effect of Outdoor Air Quality on Childhood Asthma," *Journal of Health Economics* 23, no. 6 (2004): 1209–36, https://doi.org/10.1016/j.jhealeco.2004.05.002; Ketan Shankardass et al., "Parental Stress Increases the Effect of Traffic-Related Air Pollution on Childhood Asthma Incidence," *Proceedings of the National Academy of Sciences* 106, no. 30 (2009): 12406–11, https://doi.org/10.1073/pnas.0812910106.

risks of adverse birth outcomes, mothers with low educational attainment were found to be more vulnerable.[92] While there is a positive association between educational attainment and health, racial and ethnic minorities gain fewer health benefits from educational attainment than Whites.[93]

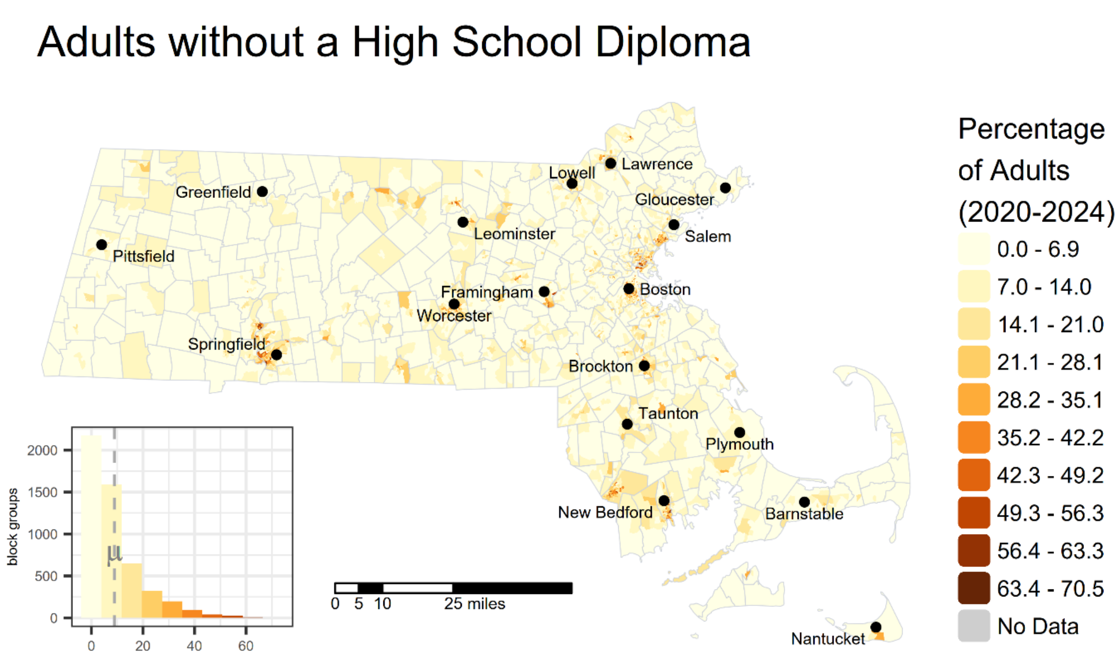
Method: The ACS education information is captured in the table Educational Attainment for the Population 25 Years and Over (ACS Table ID: B15003) at the census block group level. Percentage with less than a high school education is calculated as the sum of adults with 12th grade education but no diploma or lower level of education, divided by the total number of adults age 25 and older.

Data years: 2020 – 2024

Originating geographic scale of data: census block groups

Source: US American Community Survey 5-year Estimates for 2020 – 2024.

Figure 33 - Map of Adults without a High School Diploma raw values



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[92] Neil Thayamballi et al., "Impact of Maternal Demographic and Socioeconomic Factors on the Association Between Particulate Matter and Adverse Birth Outcomes: A Systematic Review and Meta-Analysis," *Journal of Racial and Ethnic Health Disparities* 8, no. 3 (2021): 743–55, https://doi.org/10.1007/s40615-020-00835-2.
[93] Shervin Assari, "Blacks' Diminished Return of Education Attainment on Subjective Health; Mediating Effect of Income," *Brain Sciences* 8, no. 9 (2018): 9, https://doi.org/10.3390/brainsci8090176; Caryn N. Bell et al., "Racial Non-Equivalence of Socioeconomic Status and Self-Rated Health among African Americans and Whites," *SSM - Population Health* 10 (April 2020): 100561, https://doi.org/10.1016/j.ssmph.2020.100561.

Housing Burdened Low Income Households

Definition: Percent of households that are both low income (making less than 80% of the HUD Area Median Family Income) and severely burdened by housing costs (paying greater than 50% of their income to housing costs).

Description: Areas where low-income households may be stressed by high housing costs can be identified through the Housing and Urban Development (HUD) Comprehensive Housing Affordability Strategy (CHAS) data. This indicator measures households earning less than 80% of HUD Area Median Family Income by county and paying greater than 50% of their income to housing costs. The indicator takes into account the regional cost of living for both homeowners and renters, and incorporates the cost of utilities. CHAS data are calculated from US Census Bureau's American Community Survey (ACS).

Indicator type: *Socioeconomic Factors*

Rationale: Housing cost-burdened communities are impacted by a reduced economic capacity to satisfy basic needs. Economic capacity also impacts environmental exposures, household quality, and environmental health resilience (e.g., health status, lifestyle, access to health services).[94] Housing cost-burdened communities tend to live in proximity to areas with higher environmental hazards, such as industrial sites, waste management facilities, and high-traffic density areas. Environmental inequities in housing cost-burdened communities are important, especially when other social factors converge (e.g., communities of color, lower levels of education).

Method: Data provided at census tract level. All census block groups received the percentage value for the census tract in which they are located.

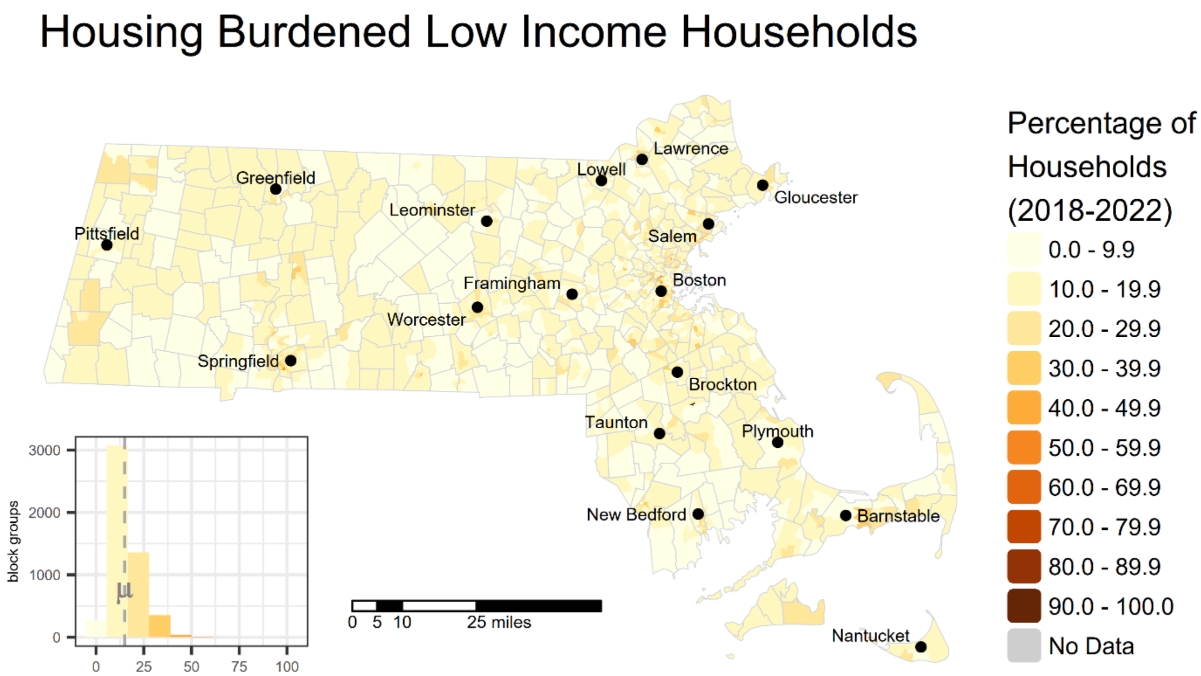
Data years: 2018 – 2022

Originating geographic scale of data: census tract

Source: US Department of Housing and Urban Development CHAS (Comprehensive Housing Affordability Strategy) at https://www.huduser.gov/portal/datasets/cp.html

[94] US Department of Health and Human Services, "Social Determinants of Health - Healthy People 2030 | Odphp.Health.Gov," accessed July 23, 2025, https://odphp.health.gov/healthypeople/priority-areas/social-determinants-health.

Figure 34 - Map of Housing Burdened Low Income Households raw values



Linguistic Isolation

Definition: Percentage of limited English-speaking households.

Description: A limited English-speaking household is defined as a household in which no one age 14 or over speaks English at least "very well" as reported in the U.S. Census Bureau's ACS. Limited English proficiency affects how well people can access services and information in their community, such as public notices about environmental contamination. Linguistic isolation describes individuals and households that have limited English proficiency or speak languages other than English at home.

Indicator type: *Socioeconomic Factors*

Rationale: Linguistic isolation indicates communities that could be less resilient to climate and environmental risks.[95] Those communities might be less informed about environmental risks (e.g., air quality alerts or water violations) and climate risks (e.g., heat, flood, drought, and wildfire alerts) when information about those risks is only made available in English. Furthermore, linguistically isolated households may also have less access to health information (e.g., healthy lifestyles or disease screening), health care services (e.g., insurance or disease treatment), and environmental health actions (e.g., incentives for housing weatherization or pollution clean-ups). Linguistic isolation is highly correlated with income, and as mentioned in the low-income indicator, income impacts environmental exposures, household quality, and environmental health resilience.

Method: The ACS limited English speaking household information is captured in the table Household Language by Household Limited English Speaking Status (ACS Table ID: C16002) at the census block group level. Percentage limited English speaking households is computed as the sum of Limited English speaking households whose primary language spoken at home is Spanish, Other Indo-European languages, Asian/Pacific Island languages, and other languages, divided by the total number of households.

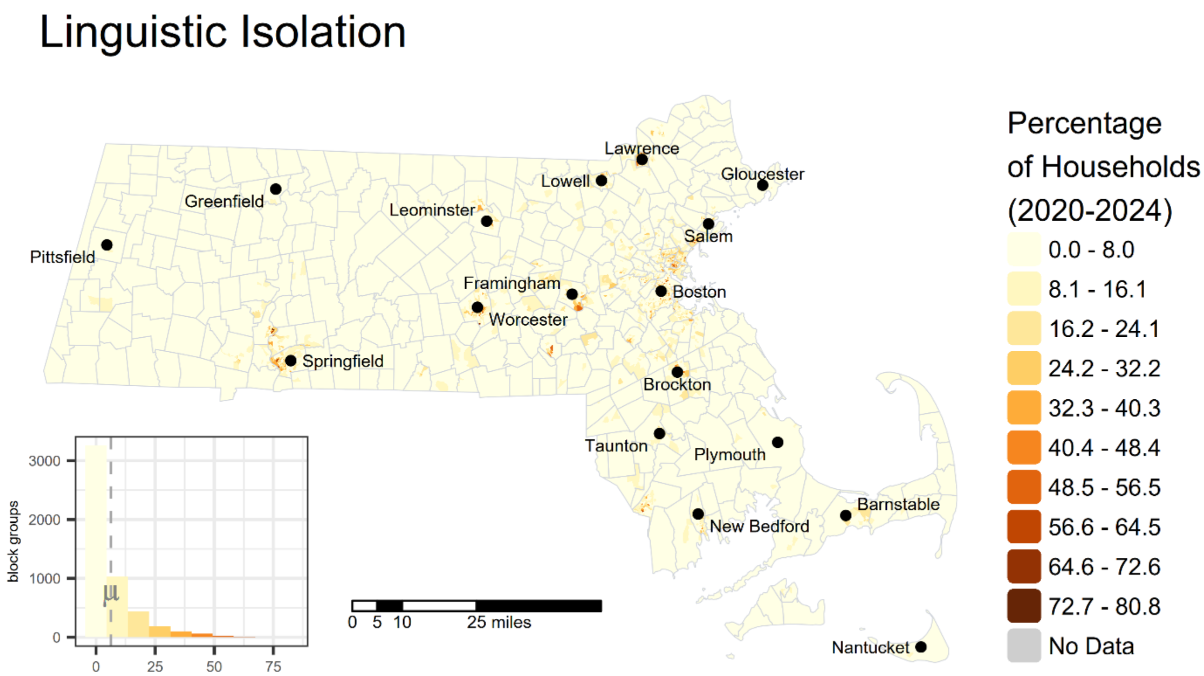
Data years: 2020 – 2024

Originating geographic scale of data: census block groups

Source: US American Community Survey 5-year Estimates for 2020 – 2024

[95] US Department of Health and Human Services, "Social Determinants of Health - Healthy People 2030 | Odphp.Health.Gov."

Figure 35 - Map of Linguistic Isolation raw values



Median Household Income

Definition: Median household income in the past 12 months (in 2023 inflation-adjusted dollars).

Description: Median household income describes the household income within a census block group that is the median, or 50th percentile, for that block group. In other words, 50% of households within a given census block group have incomes below the median value, and 50% of households are above the median value for that census block group.

Indicator type: *Socioeconomic Factors*

Rationale: Household income is an important social determinant of health. Numerous studies have suggested that lower income populations are more likely than wealthier populations to experience adverse health outcomes when exposed to environmental pollution or other stressors. Median household income, rather than mean or average household income, is unaffected by outliers or extreme low or high household income values within a given block group.

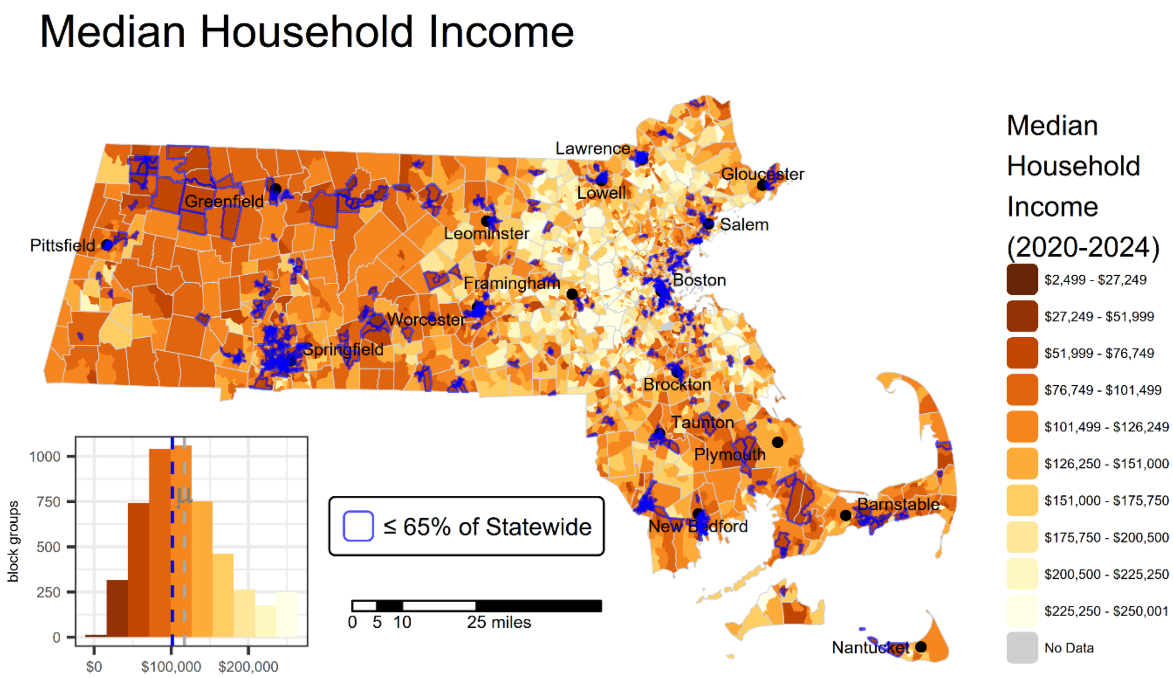
Method: The ACS median household income information is captured in the table Median Household Income (ACS Table ID: B19013) at the census block group level. 439 census block groups are missing median household income values, likely due to data suppression as a result of higher uncertainty or low response rates. 400 of these values were imputed using the median household income of the census tract in which they reside for the same time period.

Data years: 2020 – 2024

Originating geographic scale of data: census block groups

Source: US American Community Survey 5-year Estimates for 2020 – 2024

Figure 36 - Map of Median Household Income raw values



Poverty

Definition: Percent of households whose income is less than or equal to twice the federal poverty level.

Description: Income is strongly associated with health outcomes, environmental exposures, and access to, or quality of services. This indicator describes how many people in a community live at or below twice the federal poverty level. The poverty level is a national number and the same across all geographic regions. To accommodate differences in the varying costs of living across the United States and other factors, analysts typically use twice the poverty level to capture low-income households, especially in high-cost areas such as Massachusetts. In 2024, twice the federal poverty threshold meant an annual household income of $64,260 or less for a family of four.

Indicator type: *Socioeconomic Factors*

Rationale: Income correlates with access to better services and goods and is associated with better health outcomes and life expectancy. Income is also associated with housing quality and climate resilience. Low-income communities tend to live in areas with more environmental pollutants (e.g., industrial sites, waste management facilities, high-traffic areas) and climate hazards (heat islands, floods, droughts, and wildfires). Moreover, low income communities also suffer from higher disease rates, injuries, and premature mortality and have less access to public health and health care opportunities.[96]

Method: The ACS low income information is captured in the table Ratio of Income to Poverty Level in the Past 12 Months (ACS Table ID: C17002) by census block group.

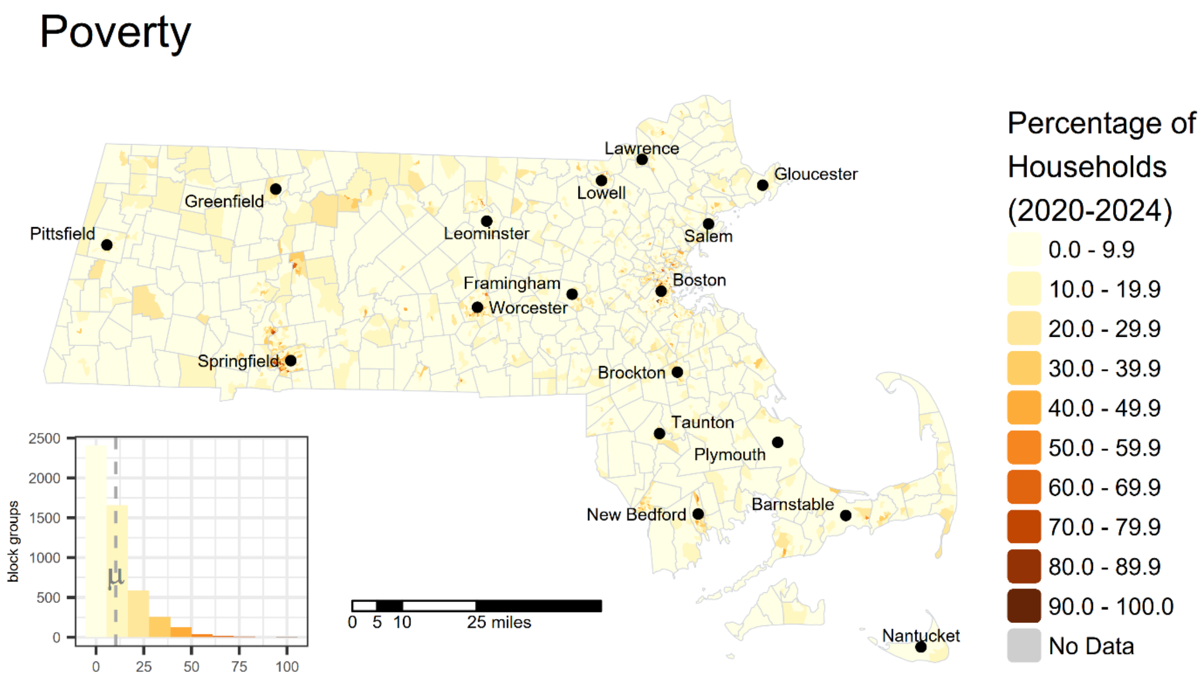
Data years: 2020 – 2024

Originating geographic scale of data: census block groups

Source: US American Community Survey 5-year Estimates for 2020 – 2024.

[96] US Department of Health and Human Services, “Social Determinants of Health - Healthy People 2030 | Odphp.Health.Gov.”

Figure 37 - Map of Poverty raw values



Unemployment

Definition: Percentage of the civilian population over the age of 16 who are unemployed and eligible for the labor force. Excludes retirees, students, homemakers, institutionalized persons except prisoners, those not looking for work, and military personnel on active duty.

Description: Unemployment impacts people's health, well-being, and quality-of-life. Many people live in poverty because they cannot find employment. In addition, some workforce participants are "underemployed", including involuntary part-time employment, poverty-wage employment, and/or insecure employment. In either case, these people struggle to afford healthy foods, health care, and safe, affordable housing, and lack the time and resources for a healthy lifestyle (e.g., exercise, mediation, stress reduction).

Indicator type: *Socioeconomic Factors*

Rationale: Unemployment has a wide range of effects on health which contribute to the burden placed on vulnerable communities. It has been shown to negatively impact mental and physical health. Higher rates of unemployment are associated with overall mortality, as well as mortality specifically due to transport accidents, poisonings (which include drug overdoses), and suicides.[97] Unemployment is also associated with increases in physical morbidity as well as mortality.

Method: The ACS unemployment information is captured in the table Employment Status for the Population 16 Years and Over (Table ID: B23025).

Data years: 2020 – 2024

Originating geographic scale of data: census block groups

Source: US American Community Survey 5-year Estimates for 2020 – 2024.

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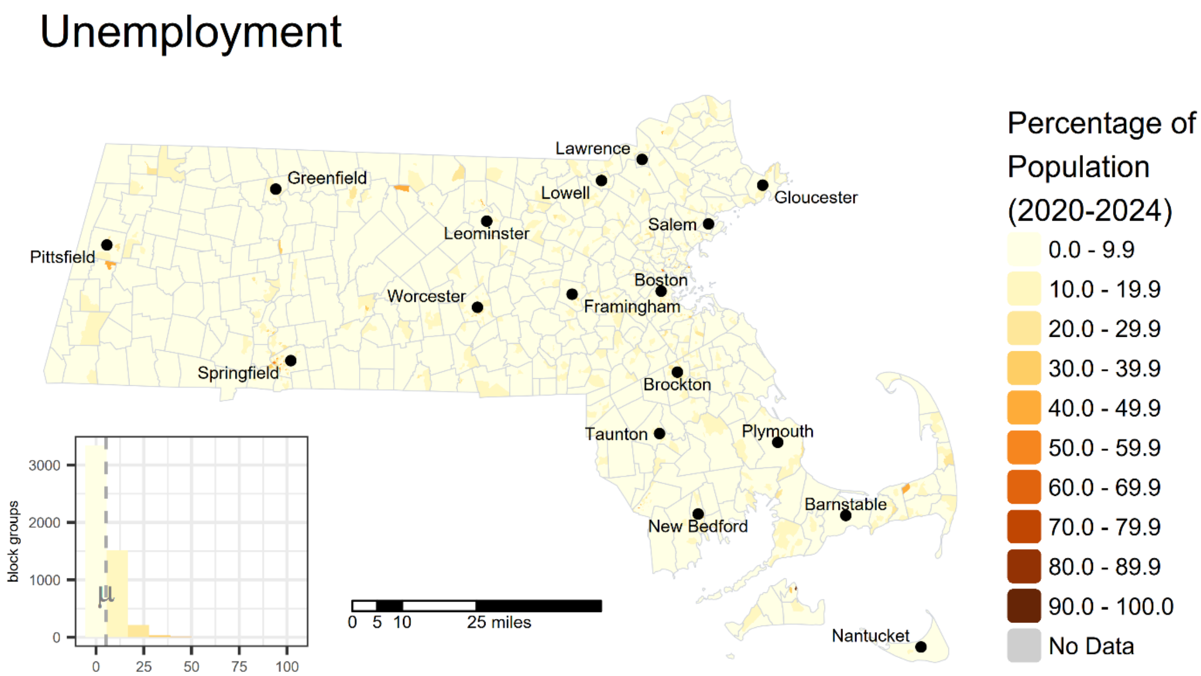
[97] Sarah H. Gordon and Benjamin D. Sommers, "Recessions, Poverty, and Mortality in the United States: 1993–2012," *American Journal of Health Economics* 2, no. 4 (2016): 489–510, https://doi.org/10.1162/AJHE_a_00060; Karsten I. Paul and Klaus Moser, "Unemployment Impairs Mental Health: Meta-Analyses," *Journal of Vocational Behavior* 74, no. 3 (2009): 264–82, https://doi.org/10.1016/j.jvb.2009.01.001; Christopher J. Ruhm, "Recessions, Healthy No More?," *Journal of Health Economics* 42 (July 2015): 17–28, https://doi.org/10.1016/j.jhealeco.2015.03.004.

Figure 38 - Map of Unemployment raw values



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Appendix A. Updates to MassEnviroScreen 2026

The final version of MassEnviroScreen (published on May 8, 2026) reflects feedback from internal and external reviews of the DRAFT version released in November 2025.

In the final version, the following indicators were revised:

- PM2.5 and Ozone
  - Replaced EJScreen source with 2022 values from (EPA) Bayesian Space-time Downscaling Fusion Model (Downscaler)
- NO2
  - Replaced EJScreen source with 2024 surface NO2 concentrations from originating research group at Cardiff University and George Washington University
- Diesel PM
  - Replaced EJScreen source with 2020 values from EPA AirToxScreen
- Drinking Water Non-Compliance Score
  - Replaced USEPA EJScreen data source with data from USEPA Safe Drinking Water Act (SDWA) Federal Reporting Service
  - Recalculated scores using all SDWA violations over last 5 years (not just those that had not yet returned to compliance as in EJScreen)
- Wildfire Risk
  - Replaced USDA Wildfire Hazard Potential values with Annualized Wildfire Impacts to Highly Valued Resources or Assets (HVRA) from Northeast-Midwest State Foresters Alliance Risk Explorer
- Drought
  - Reorganized scores by Massachusetts Drought Region, rather than by county
  - Replaced U.S. Drought Monitor drought frequency with annualized frequency of Massachusetts-declared drought events weighted by drought severity
  - Expanded from 5-year period to last 25 years (2001 – 2025)
- Flooding
  - Calculated percent of population within Special Flood Hazard Areas based on dasymetric mapping approach (developed land use area of census blocks and presence of buildings)
  - Used latest FEMA preliminary Digital Flood Insurance Rate Maps (DFIRMS) in place of MassGIS Q3 data (except for Berkshire County), and 200' riverfront buffer in Mount Washington following Massachusetts wetlands regulations
- Heat
  - Replaced count of days at 85F or higher with count of unhealthy heat events – three or more days in a row of 85F or higher temperatures

    - Expanded from 10-year period to 30-year period (1996-2025)
- Sensitive Population indicators
    - Updated CDC Places data to 2025 release
        - High blood pressure, heart disease, COPD, adult cancer
- Socioeconomic indicators
    - Updated all American Community Survey-based indicators to 2020 – 2024;
    - Updated Department of Housing and Urban Development (HUD) data on low-income housing burdened households with data from 2018 - 2022

Summary Statistics of MassEnviroScreen Nov 2025 vs MassEnviroScreen Feb 2026

Version	Burdened Areas	Total Population	Total Area (sq km)	Percent of Block Groups	Percent of Population	Percent of State Area
MES2025	1,702	2,232,881	2,310	33.3%	31.9%	10.9%
MES2026	1,751	2,360,472	2,976	34.3%	33.5%	14.1%

A total of 483 block groups (9.4%) across the state change in BA status between the two versions; 217 going from BA status to non-BA status and 266 going from non-BA status to BA status. There is a net increase of 49 BAs. Note the greater increase in total area due to an increase in BA in rural areas.

Refinements to Technical Documentation

- Expanded policy context informing the development of MassEnviroScreen
- Added description of the development process and stakeholder engagement across Massachusetts agencies, partners, and subject matter experts
- Strengthened discussion of tool limitations and appropriate use
- Expanded explanation of indicator selection criteria and parameters
- Added detail description of model components
- Clarified treatment of missing vs. zero-value data
- Enhanced explanation of score calculation, including:
    - Step-by-step example using a census block group
    - Rationale for the multiplicative approach