



# Education and Climate Change: Synthesizing the Evidence to Guide Future Research

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# **Education and Climate Change: Synthesizing the Evidence to Guide Future Research**

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## **Abstract**

The effects of climate change are becoming increasingly visible across all aspects of the U.S. PreK-12 education system. Schools are both vulnerable to climate change and uniquely positioned to be part of the solution. We synthesize interdisciplinary research and data to illustrate the bi-directional relationship between schools and our changing climate. Drawing on this evidence, we map out a research agenda around five interrelated dimensions to inform policy and practice: 1) reducing schools' environmental impacts, 2) making schools more resilient to environmental pressures, 3) supporting students and staff affected by climate change, 4) teaching about climate science, exposing students to the natural world, and providing training for jobs that advance sustainable practices, and 5) expanding the role of schools as community hubs that support broader awareness about climate change and care for the planet.

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## Introduction

Images and stories of the effects of climate change on schools are becoming a fixture of national headlines in the United States. Media often covers damage and school closures caused by extreme weather events. In 2024, Hurricane Helene kept 76,000 students in western North Carolina out of class for over a month due to storm damage (Wakeman, 2024). The 2025 Los Angeles wildfires destroyed at least a dozen K-12 schools (Jimenez, 2025). More gradual climate impacts, however, also create chronic pressures on schools. School grounds in the San Francisco Bay Area and Atlantic City, New Jersey are now prone to annual flooding due to rising sea levels (Romero, 2024; Upton et al., 2021). Rising temperatures are causing schools across the Midwest and Northeast to close during heat waves due to a lack of adequate air conditioning (Meckler, 2023). Playground surface temperatures are reaching up to 145 degrees in the Southwest, posing a safety risk to students (Reyes-Velarde, 2022). Climate models supported with widespread consensus in the scientific community predict that if we continue on our current path, the world will warm from its present 1.5°C (2.7°F) above pre-industrial averages to at least 2.7°C by the year 2100 (4.9°F) (Calvin et al., 2023; Ripple et al., 2024). If this possibility becomes an eventuality, today's headlines will seem quaint compared to the destabilizing effects that climate change will have on education systems by century's end.

Climate change is directly affecting education systems through the increased frequency and severity of extreme weather events, excessive heat and humidity, rising sea levels, and hazardous air pollution. However, schools are not just victims – they are also agents of change. The headlines' narrow focus on climate-related pressures belies a more complex, bi-directional relationship in which our education system also contributes to climate change and prepares students to tackle its challenges. Studies consistently find that educational attainment is

associated with greater awareness of climate change and willingness to contribute to solutions (Angrist et al., 2024; Semenza et al., 2008).

In this paper, we conduct a synthetic review of interdisciplinary research and data to highlight the multitude of ways that climate change and schooling in the United States are inextricably linked. While we primarily focus on formal Prek-12 education in the United States, many of the challenges and opportunities we describe are common to higher education and shared globally. We see this work as part of a larger, shared effort to understand how schools can adapt to and help address the impacts of climate change. A wide range of earth systems are also facing increasing disruption due to human activity such as industrial pollution (Richardson et al., 2023). We integrate elements of these parallel, interrelated environmental pressures such as industrial pollution into our review to provide a more comprehensive picture of how environmental degradation affects students and schools.

Our goal is to catalyze education policy research at the intersection of these topics, which we organize under five interrelated dimensions. Education systems impact the environment through their energy use, transportation services, food consumption, and land stewardship. In turn, the environmental changes driven by climate change directly impact education systems, the staff they employ, and the students they serve. Schools educate students about the science of, and solutions to, climate change. Schools provide students with the skills and knowledge necessary to advance sustainable solutions. Schools are also uniquely positioned to drive community-level awareness about the impacts of climate change given the important role they play in our society.

Efforts to advance environmental resilience and climate education in school systems are emerging across the country. Districts such as Boston, Denver, Los Angeles, Salt Lake City, Santa Barbara and Virginia Beach have developed district-wide climate action and environmental

sustainability plans with dedicated offices to oversee this work (City of Boston, 2022; Denver Public Schools, 2022; LAUSD, n.d.; Santa Barbara Unified School District Board of Education, 2018; SLCSD, 2021; Virginia Beach School Board, 2022). California, Connecticut, Maine, Maryland, New Jersey, and Washington have integrated environmental and climate education across state standards and invested in professional development and additional educational resources for teachers instructing students on climate change (Elder et al., 2023; Maryland State Department of Education, 2010). The Colorado state legislature recently approved a high school endorsement in climate literacy (Seal of Climate Literacy Diploma Endorsement, 2024).

However, PreK-12 education policy and practice in the United States does not reflect the urgent need to address the environmental impact of schools, improve their resiliency, and prepare students for a changing climate. Climate change is described as a “wicked problem” because its effects are often experienced as disparate and isolated, contributing factors can be nebulous, levers of change are not always clear, and its individual components are sometimes framed as problems for other areas of policy (Peters & Tarpey, 2019). Federal programs and incentives have been substantially curtailed by severe funding reductions, staffing cuts, and executive orders under the current administration. The complexity and global scale of climate change combined with the history of slow, incremental education reforms in our decentralized education system have resulted in a patchwork of policies, programs, and practices rather than a coordinated, sector-wide effort to see climate change as an education policy issue.

The research community similarly lacks coordination and cooperation to address these issues, limiting our ability to advance interdisciplinary research to better inform education policymakers. Rigorous and policy relevant research across the social sciences and STEM fields has begun to illuminate the multitude of ways in which education systems and climate change

interact. Yet these different strands of inquiry often remain isolated in disciplinary silos and at arm's length from education policy. With few exceptions, there are almost no climate change-related panels or special interest groups at conferences of the major professional education research associations.<sup>1</sup> This fragmentation and lack of community narrows the scope of issues studied and frames them as individual concerns rather than symptoms of a much larger problem. We posit that the research community has a central role to play in supporting schools' efforts to adapt their design and role as our climate changes – one that the field has yet to entirely fulfill.

In contrast to a more systematic review, we map the research landscape by synthesizing disparate literatures and data to identify key themes and present first order facts. By doing so, we hope to develop the contours of a prospective research agenda and invite more interdisciplinary and cross-sector collaborations about the nature of this challenge. How much money does climate change cost public schools every year? What if investments in modern, sustainable school infrastructure compared favorably to other common interventions to reduce student absenteeism and raise achievement? What if teaching about climate science equipped students and their communities with the knowledge and will to change the current environmental trajectory? We need rigorous evidence to answer questions like these and many more.

Our paper builds on several recent publications that have begun to illustrate the far-reaching relationship between schooling and climate change on a global scale (GEM Report UNESCO, 2024; Samie-Jacobs, 2025; Smithsonian Science Education Center, 2023; UNESCO, 2021; Venegas Marin et al., 2024). Our work also complements parallel efforts to frame

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<sup>1</sup> For example, of the 152 American Educational Research Association Special Interest Groups, only one focuses on the environment or climate change (Environmental Education). Of the 164 combined paper panels across both the Association for Education Finance and Policy (AEFP) and the Society for Research on Educational Effectiveness annual conferences in 2024, we found only one related panel: “Estimating the impact of pollution on academic outcomes.”

education as critical to advancing planetary health (Gehlbach et al., 2024) and to develop an education and climate policy agenda (Hengtgen & Rodick, 2025; Schifter & Klein, 2025; The Aspen Institute, 2021). In the sections below, we document the broad dimensions where education systems and climate change intersect, characterizing the phenomena involved and what is known about them.

### **Identifying Thematic Dimensions**

Our exploration of research at intersection between education systems and climate change proceeded in three stages. First, we conducted an inductive, interdisciplinary scan of work on these topics. The genesis of this effort arose from a collaborative design process for an undergraduate course, “K-12 Education Systems and Climate Change,” supported by a team of undergraduate and graduate students with diverse academic backgrounds who conducted exploratory searches on related topics. We cast a wide net to include products such as policy briefs, white papers, blog posts, and websites in addition to traditional academic research. We did not specify inclusion criteria but rather took a more responsive, inductive approach, aiming to capture the breadth of issues instead of comprehensively covering specific literatures.

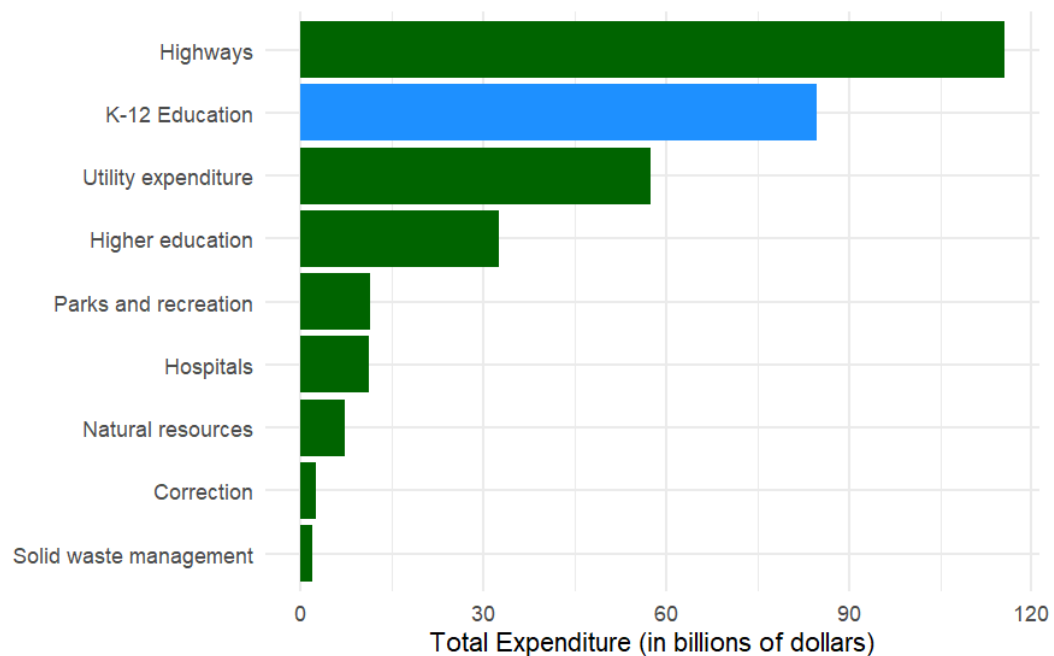
In our second phase, we identified five macro, interrelated dimensions from this process, which we think characterize the field: 1) schools’ impacts on the environment, 2) the impacts of climate change on school operations, 3) the impacts of climate change on students, 4) climate and nature-based education as well as job training for careers that contribute to climate solutions, and 5) the role of schools in advancing community-wide efforts for resilience and sustainability. In Table 1, we present an overview of some of the topics that fall under each of these dimensions as well as example research questions. Third, we collected descriptive data to contextualize the existing knowledge base, particularly in areas where academic research is sparse (Loeb et al.,

2017). We integrate statistics, visual representations, and high-level facts with existing academic literature to provide context, illustrate gaps, and motivate future work.

### **Dimension #1: The Environmental Impacts of the U.S. PreK-12 Education System**

The U.S. PreK-12 public education system represents the second largest public infrastructure system in the country with almost 100,000 buildings. As shown in Figure 1, state and local government capital expenditures on elementary and secondary public schools exceed \$75 billion each year – second only to highways (ASCE, 2021).

**Figure 1.** State and local government capital outlay by category



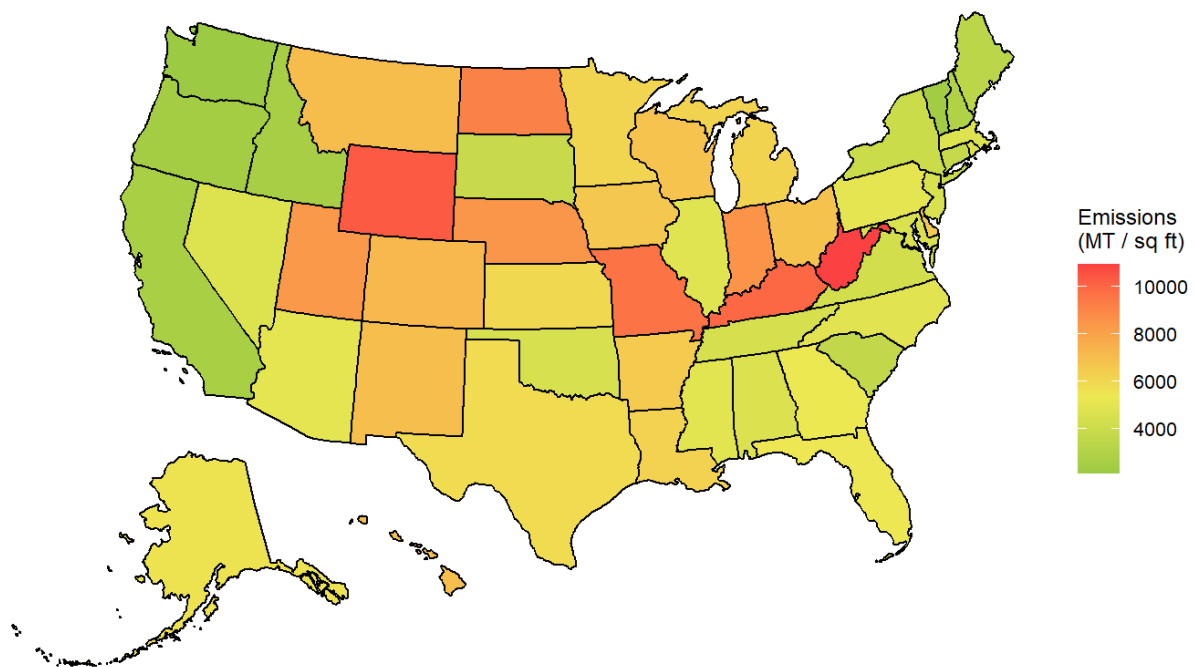
Sources: U.S. Census Bureau, State and Local Government Finances, 2022.

Note: Capital outlay refers to direct expenditures for the purchase or construction of buildings, land, equipment, and other improvements, whether carried out by contract or employees. It also includes payments on capital leases.

Schools occupy 7.8 billion gross square feet and manage about 2 million acres of land, roughly twice the area of Rhode Island (New Buildings Institute, 2021; The Aspen Institute, 2021).

Estimates suggest that public school infrastructure contributes between 41 and 72 million metric tons of annual emissions (Lieberman, 2022; New Buildings Institute, 2021). While only about 1% of total U.S. emissions (EPA, 2024), this is roughly equivalent to the annual emissions of 18 coal-fired power plants or 15 million cars (Bauld, 2021; New Buildings Institute, 2021). However, there is substantial variation in the carbon footprint of education systems across states due in part to the age of school building infrastructure, heating and cooling requirements of the local climate, and locally available power sources. As shown in Figure 2, public schools in Wyoming and West Virginia produce more than three times as many metric tons of carbon per square foot of building space as those in Washington and Vermont.

**Figure 2.** Annual carbon emissions for public K-12 buildings

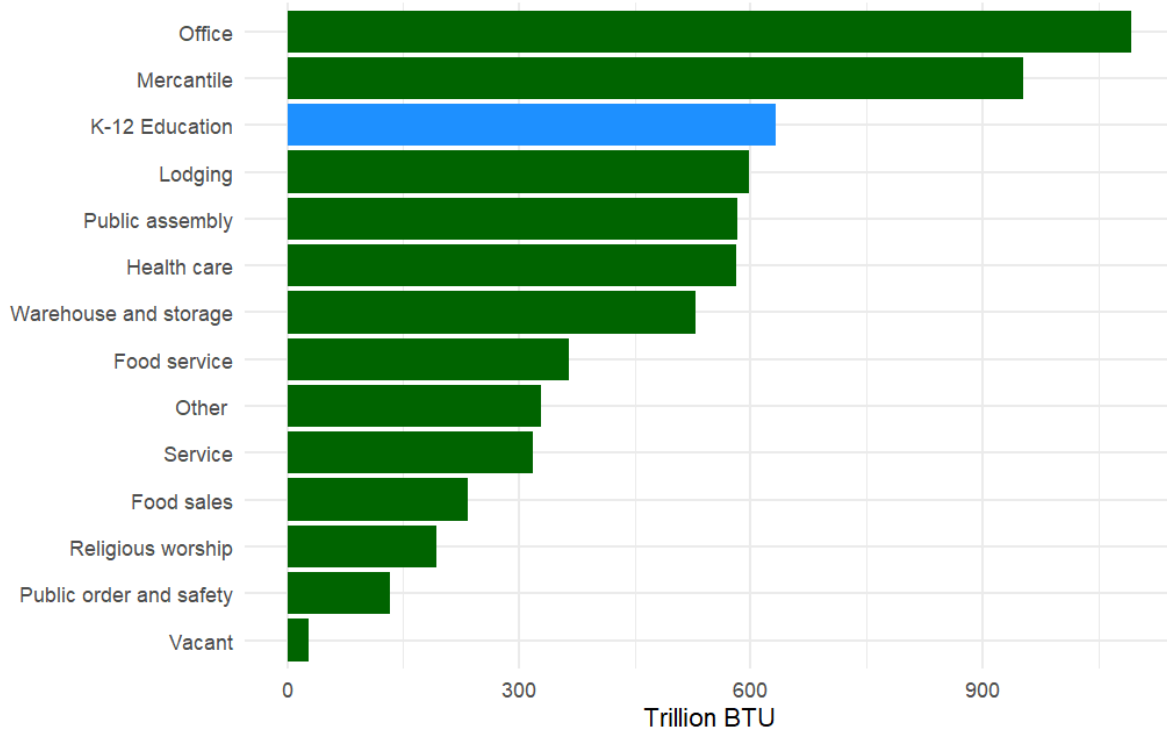


Sources: New Buildings Institute, 2021.

Note: This graph represents the estimated metric tons (MT) of carbon emissions per square foot in public K-12 school buildings. See Appendix Table A1 for state-specific reported emissions values.

School buildings consume substantial amounts of energy each year. K-12 schools are the third-highest energy consumers of all commercial building types (see Figure 3), using nearly 600 trillion British thermal units (BTU). This is enough energy to power approximately 16.3 million U.S. homes for a year, based on average residential electricity consumption (EIA, 2024).

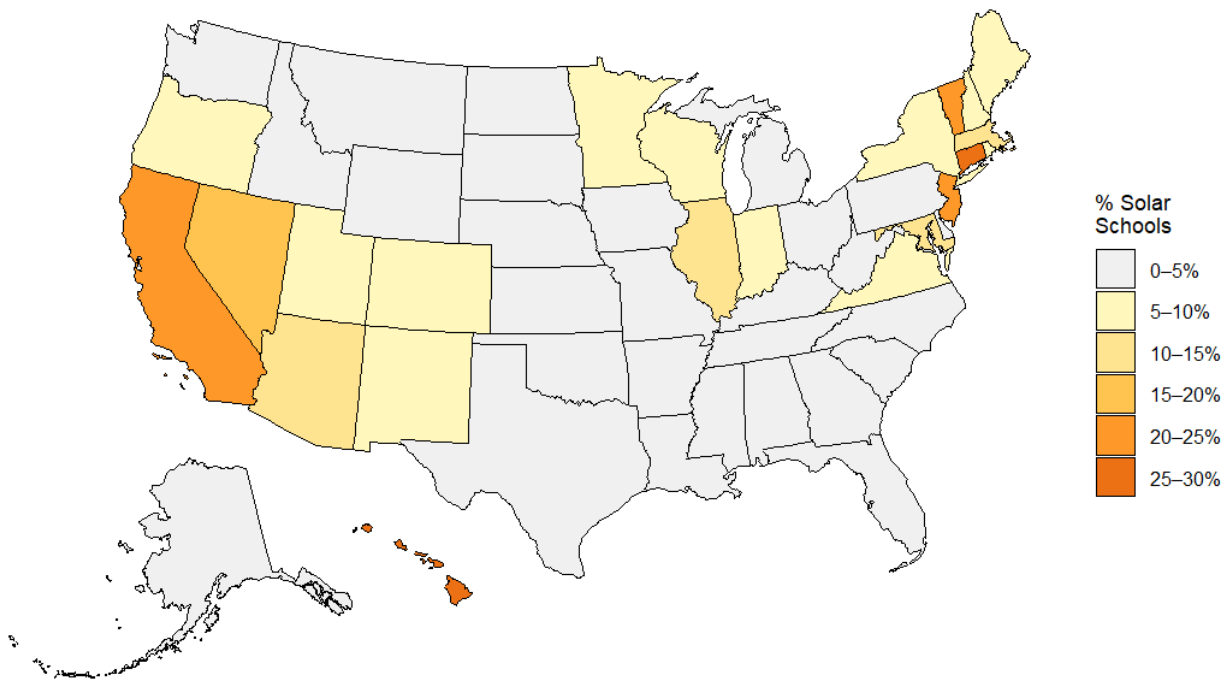
**Figure 3.** Energy consumption by building activity



Sources: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey (2018).  
Note: BTU (British Thermal Unit) is a measure of energy used to compare different fuel sources.

Currently, fewer than 10% of K-12 schools are benefitting from onsite solar energy, illustrating large potential for reductions of carbon emissions (Generation180, 2024). Figure 4 highlights the variation in solar energy use in K-12 schools across the United States. Five states (NJ, VT, CA, CT, HI) and the District of Columbia leverage solar energy in over 20% of their schools, while in 27 states, less than 5% of schools benefit from solar.

**Figure 4.** Percentage of schools using solar energy by state

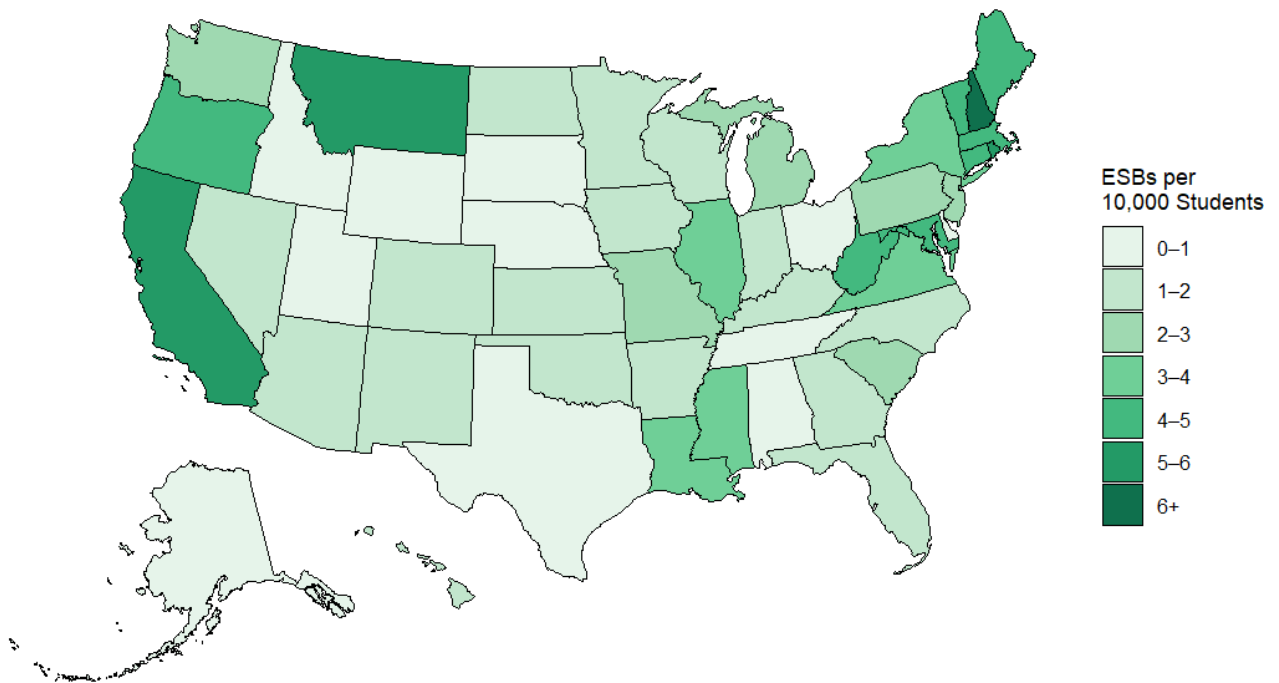


Sources: Generation180, National Center for Education Statistics.

Note: Includes schools utilizing solar energy from any source, including offsite solar farms, green power purchases, and land lease revenue arrangements. Includes both public and private schools (2022-2023 public schools, 2021-2022 private schools). See Appendix Table A1 for state-specific values for solar school penetration.

School bus fleets also contribute to the K-12 education system's carbon footprint. There are approximately 480,000 school buses in the United States, making up the nation's largest public transportation fleet (NYSBCA, n.d.). Most of the nation's school buses are diesel powered. As of October of 2024, funding or purchase agreements were in place for roughly 12,000 electric school buses across the United States – still less than 3% of all vehicles (Freehafer et al., 2024). Figure 5 demonstrates the considerable variation in the rate states are electrifying their school bus fleets: New Hampshire, Rhode Island, and California have committed over five electric buses per 10,000 students, while states Texas, Alabama, and Ohio have fewer than 1 electric bus per 10,000 students. This variation likely reflects not just differences in need or fleet size, but also state priorities, funding, and administrative capacity.

**Figure 5.** Committed electric school buses per ten thousand students by state



Sources: World Resources Institute, National Center for Education Statistics.

Note: An ESB is considered “committed” starting from the point when a school district or fleet operator has been awarded funding to purchase it, or has made formal agreement to purchase it from a manufacturer or dealer. Data reflects ESB commitments for public school districts across U.S. states. See Appendix Table A1 for state-specific committed buses per 10,000 students.

In addition to energy and transportation, the food sourced and served by schools has a considerable carbon footprint. Schools serve over 7 billion meals annually (The Aspen Institute, 2021). Food waste from those meals generates an estimated 1.9 million metric tons of carbon dioxide (CO<sub>2</sub>) equivalent emissions in the production process, and another 217,500 metric tons of CO<sub>2</sub> equivalent from decomposition in landfills, primarily as methane (The Aspen Institute, 2021; World Wildlife Fund, 2019). A recent study examining school lunch menus across six U.S. urban school districts found that the average carbon emissions per meal was 1,737 grams; meals containing beef had the highest greenhouse gas emissions and plant-based meals had the lowest (Boronowsky et al., 2025; Stern et al., 2022). Thus, serving an individual school lunch is roughly

the equivalent of driving 4.3 miles in a gasoline-powered car. Large amounts of food waste further compound the environmental impact of school meal programs. Schools produce 530,000 tons of food waste per year (The Aspen Institute, 2021). Much of this waste is transferred to landfills, which further emit methane into the atmosphere. As of 2020, only 14 states had programs promoting schools to divert food waste and only 6 had policies to promote composting at schools (The Aspen Institute, 2021).

With more than 13,000 school districts across the country, the U.S. public education system has potential to become a market driver for innovation around sustainable construction and clean energy. Teachers' unions also represent powerful interest groups that can shape both local decisions and the national political discourse around the importance of addressing climate change. For example, the American Federation of Teachers (AFT), the second largest teachers' union in the country, adopted a resolution in 2022 to advocate for teacher pension funds to divest from fossil fuel industries (American Federation of Teachers, 2022).

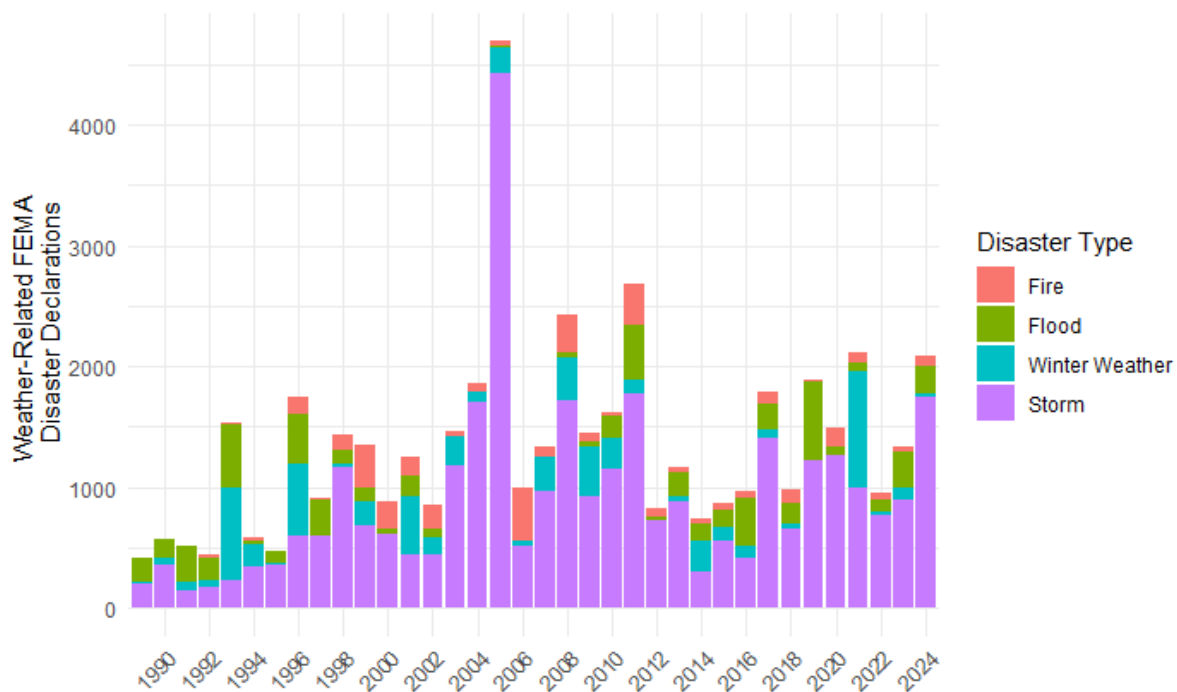
While we have the data necessary to arrive at rough estimates of the U.S. public education system's carbon footprint, we lack research that systematically documents and quantifies emission reduction efforts in the education sector. Understanding what infrastructure and transportation system investments most effectively reduce both emissions and costs across diverse contexts will be key evidence to inform policy decisions. Research on food selection, sourcing, and preparation in U.S. public schools can also inform cross-cutting efforts to reduce food waste, increase the nutritional content of school meals, and support local economies.

## **Dimension #2: Climate Change Impacts on School Infrastructure, Budgets, and Operations**

Schools across the United States are increasingly vulnerable to the chronic and acute effects of environmental degradation. Research illustrates that human-caused climate change is

accelerating the frequency and intensity of extreme weather events (Abatzoglou & Williams, 2016; IPCC, 2021). The frequency of weather-related Federal Emergency Management Agency (FEMA) disaster declarations has more than tripled over the past 35 years (see Figure 6). The intensity of storms, approximated by their economic costs, has also increased rapidly over recent decades. The National Centers for Environmental Information at the National Oceanic and Atmospheric Administration have tracked weather and climate disasters exceeding \$1 billion in (inflation-adjusted) damage costs since 1980. As indicated in Figure 7, the frequency of domestic billion dollars disasters has risen from an average of 3 events in the early 1980s to 23 in the early 2020s – a more than 600% increase. These disasters almost invariably affect PreK-12 schools given their presence in communities across the entire country.

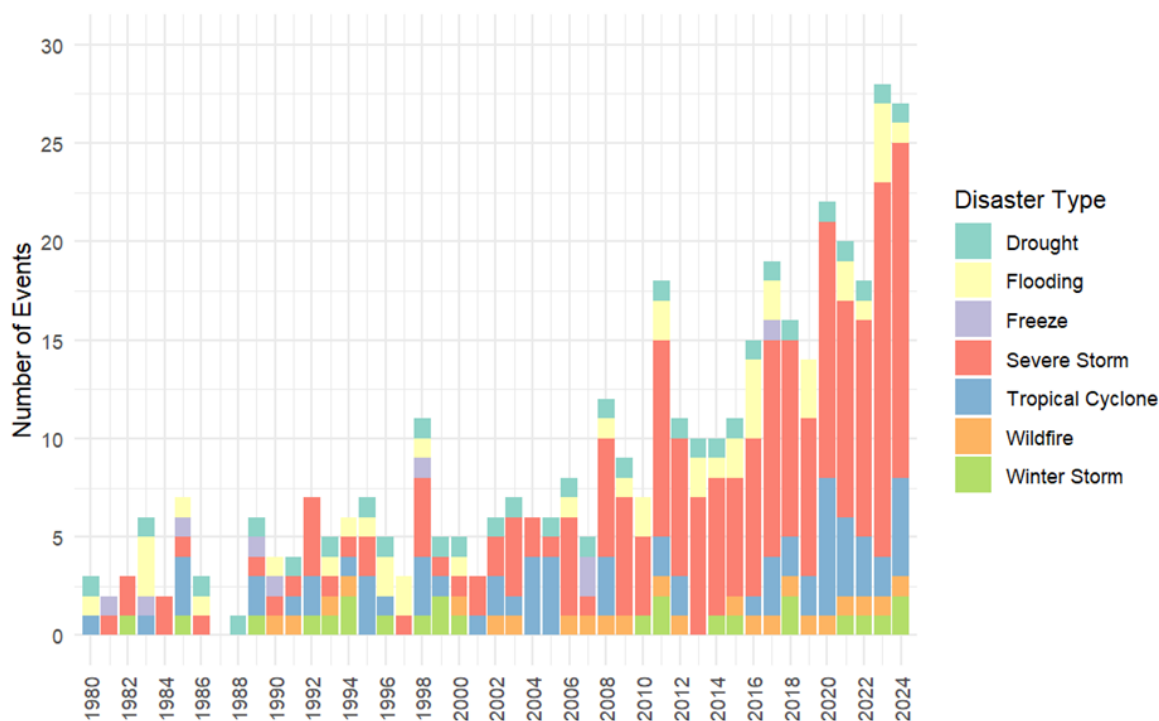
**Figure 6.** Total annual weather-related FEMA disaster declarations by type



Sources: Federal Emergency Management Agency (FEMA), OpenFEMA Dataset: Disaster Declarations Summaries - v2. Retrieved from <https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2> on January 24, 2025, 12:25 PM EST. This product uses the FEMA OpenFEMA API, but is not endorsed by FEMA. The Federal Government or FEMA cannot vouch for the data or analyses derived from these data after the data have been retrieved from the Agency's website(s).

Note: The disaster categories are summarized as follows: Fire includes incidents of type 'Fire'; Flood includes incidents of type 'Flood' and 'Tsunami'; Winter Weather includes incidents of type 'Winter Storm', 'Snowstorm', 'Severe Ice Storm', and 'Freezing'; Storm includes incidents of type 'Severe Storm', 'Hurricane', 'Coastal Storm', 'Tropical Storm', 'Typhoon', and 'Straight-Line Winds'.

**Figure 7.** Total number of U.S. billion-dollar weather and climate disasters (CPI-adjusted)

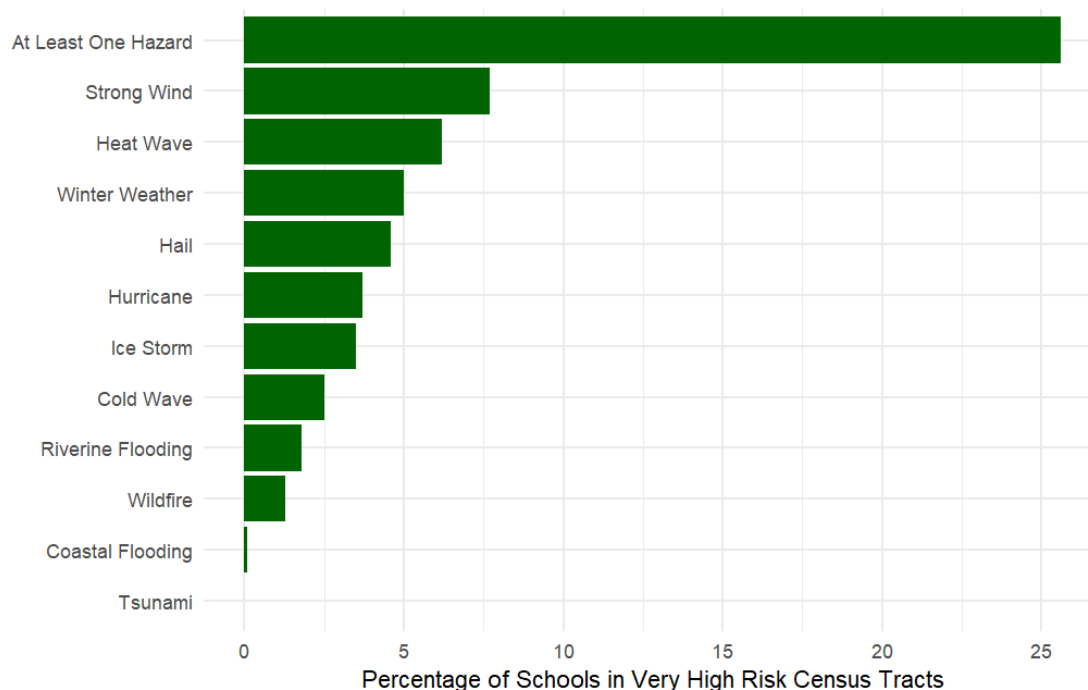


Sources: NOAA National Centers for Environmental Information

Note: This graph replicates a visualization from NOAA's National Centers for Environmental Information on Billion-Dollar Weather and Climate Disasters. All data are adjusted for inflation using the Consumer Price Index (CPI) by NOAA.

Using FEMA data, we estimate that 24,500 public schools, approximately 25% of all public schools, are located in census tracts that face a very high risk from at least one of the following hazards: coastal flooding, cold wave, hail, hurricane, heat wave, ice storm, riverine flooding, strong wind, tsunامي, winter weather, or wildfire (see Figure 8).

**Figure 8.** Percentage of public schools located in census tracts classified as ‘Very High Risk’ by FEMA’s National Risk Index



Sources: FEMA National Risk Index, National Center for Education Statistics.

Note: Percentages are based on all U.S. public schools. Risk is determined by matching each school to the FEMA National Risk Index score of its corresponding census tract. Individual hazard categories represent the share of schools in tracts rated Very High for that specific hazard. Schools are only counted once in the ‘At Least One Hazard’ category but may be counted across multiple specific hazard categories.

As environmental-related pressures and extreme weather events become more regular and severe, schools must prepare for the consequences of such disasters including damage to infrastructure, strain on budgets, and disruptions to operations.

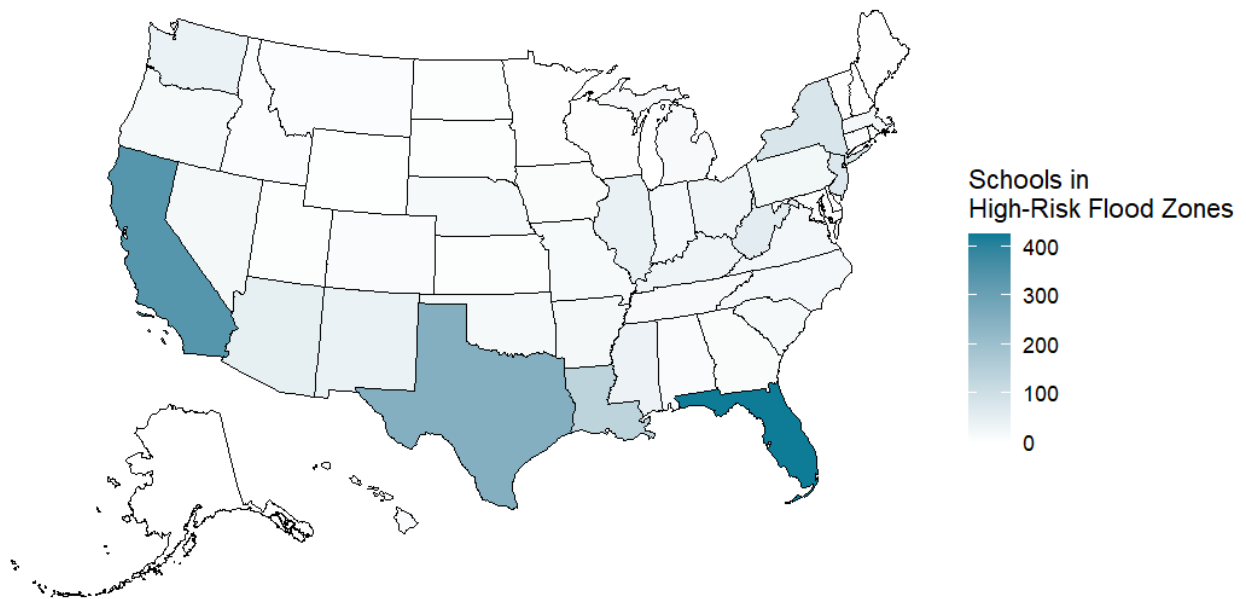
### Impacts on Physical Infrastructure

Climate change stresses the already weak school infrastructure in the United States. In 2020, about half of school districts participating in a U.S. Government Accountability Office survey reported that they needed to replace or repair their capital infrastructure such as heating, ventilation, air conditioning, or plumbing (GAO, 2020). The American Society of Civil Engineers gave schools a D+ in its 2025 report card for America’s infrastructure (ASCE, 2025).

The nation currently spends \$99 billion per year on school maintenance, operations, and construction – well short of the \$145 billion needed to create learning environments that fully support student needs according to the 21st Century School Fund (21st Century School Fund, 2016). Despite the vast size of the U.S. education system, public schools have historically been excluded from federal infrastructure legislation (Modaffari & Alleyne, 2022). About 82% of capital funding for public school buildings comes from local revenues, while federal sources contribute less than 1%, a stark contrast to its much larger investments in highways and waterways (L. Jimenez, 2019). Reliance on local funding for public school capital projects creates large inequities in the health and safety of school infrastructure that cut across racial and socio-economic lines (Brunner et al., 2023; GAO, n.d.; Turner et al., 2016). Some states offer credit enhancement to municipalities to reduce school bond interest costs, shrinking the gap in capital funding access between low- and high-income districts (Yang, 2024).

The dispersion of school buildings across the United States places them at considerable risk to a range of extreme weather events. Figure 9 highlights the vulnerability of over 2,000 schools serving approximately 4 million students in flood-prone areas, with large coastal states such as Florida, California, Texas, and Louisiana having a particularly high numbers of buildings located in flood plains (Lightbody, 2017). Hundreds of schools in New York City were affected by flooding caused by heavy rains from Tropical Storm Ophelia in September of 2023 (Zimmerman, 2024). The impacts of flooding can also be acute along inland rivers and ravines as evidenced by the damage and flooding caused by Hurricane Helene in 2024 (Parker, 2025).

**Figure 9.** Number of schools in high-risk flood zones



Sources: FEMA National Flood Hazard Layer, National Center for Education Statistics Public School Locations 2023-24.

Note: Includes schools in FEMA-designated high-risk flood zones (A, AE, AH, AO, A99, VE), which have a 1% annual chance of flooding (100-year floodplain). See Appendix Table A1 for state-specific values for the number of schools in flood zones.

Climate change has also accelerated the frequency and intensity of wildfires that threaten schools. Following the 2018 Camp Fire, almost 5,000 students and staff of the Paradise Unified School District in California were evacuated, and two school buildings completely collapsed (Hamideh et al., 2022). Most recently, the 2025 Los Angeles wildfires destroyed at least a dozen K-12 schools (Jimenez, 2025). As these disasters take place more frequently and in more parts of the country, schools nationwide are at greater risk of damage and disruption.

### Financial Consequences for Schools

Both chronic pressures from global warming and extreme weather events create added financial burdens for districts already struggling to maintain aging facilities. Schools

increasingly need to retrofit buildings to withstand more extreme weather conditions and environmental pressures. For example, the Center for Climate Integrity estimates that the cost of installing HVAC systems in schools where they were unnecessary before 1970 will exceed \$40 billion by 2025 (LeRoy et al., 2021). The cost of rebuilding and repairing damaged school infrastructure can also be substantial. For instance, it cost \$2 billion to repair 110 school buildings which had been destroyed by Hurricane Katrina (Hawkins, 2024). In 2017, after Hurricane Harvey devastated the Houston Independent School District, costs to rebuild several elementary schools totaled \$126 million (Talarico, 2017).

Districts vulnerable to extreme weather are also experiencing rising costs to insure their facilities (Lieberman, 2023). Districts typically obtain property insurance through private companies, public providers, or risk-pooling district collectives. In the aftermath of Hurricane Ida, NOLA Public Schools' property insurance costs increased by 47% from \$7.6 million in 2021-22 to \$11.2 million in 2022-23 (Jewson, 2023). These rising costs are likely due to the growth of insurance claim payouts. Payouts from the Missouri United School Insurance Council, which provides coverage to 90% of the state's school districts, have more than doubled since 2017 due in large part to the rising number of extreme weather events (Fortino, 2024).

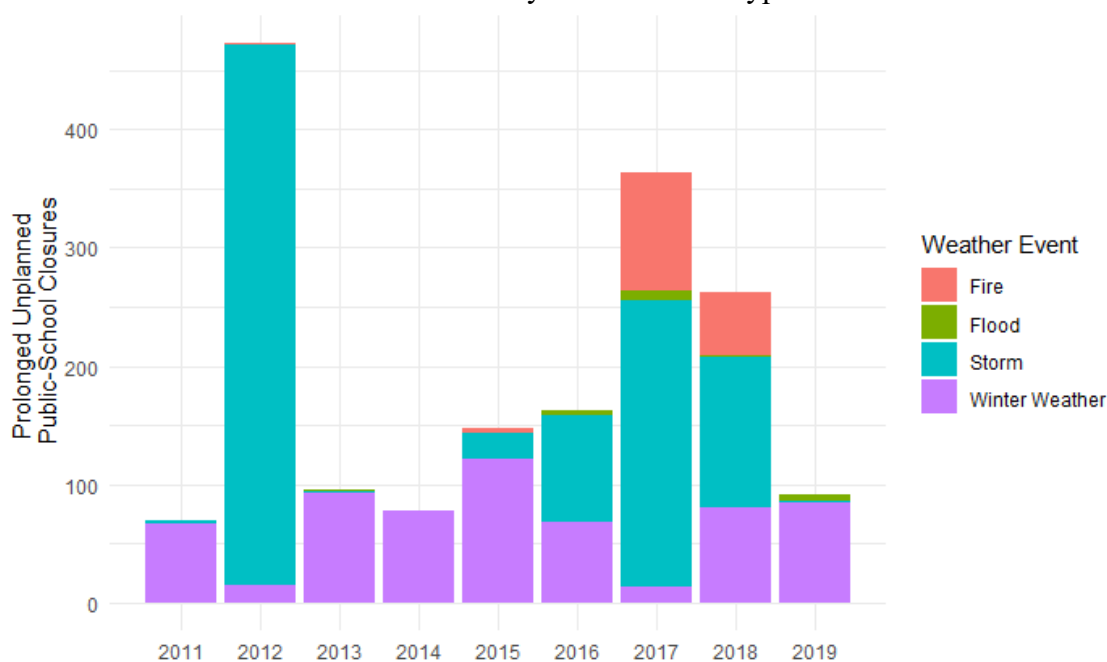
Population loss compounds the financial pressures climate change places on schools. Communities affected by disasters often experience a decline in residents due to damaged homes and job losses. Rising temperatures and sea levels have also begun to shape migration patterns within the U.S. Demographers predict major increases in internal migration away from cities facing prolonged temperatures of over 100 degrees such as Phoenix and low-lying cities on the Eastern Seaboard and Gulf of Mexico such as Miami (Craig, 2024). Subsequent declines in student populations can create a lasting budgetary strain as federal and state funding is usually

calculated on a weighted per-pupil basis (GAO, 2022). Population declines and damage to local infrastructure and business can also lower local tax revenue available to fund public education.

### Impacts on School Operations

Extreme temperatures, poor air quality, and weather-related disasters can dramatically disrupt normal school operations. Although we lack the data to track changes in the frequency and severity of weather-related disruptions due to climate change over a long period, data on school closures collected by the Center for Disease Control (CDC) and the national nonprofit UndauntedK12 illustrate the scope of the challenges. Between 2011 and 2019, extreme weather caused 83% of closures lasting a week or more, impacting over 1,200 school districts across the U.S. (see Figure 10) (Jahan et al., 2022). As shown in Figure 11, data collected by UndauntedK12 between 2021 and 2025 document how millions of students are affected each year by weather-induced school and extracurricular cancellations and disruptions.

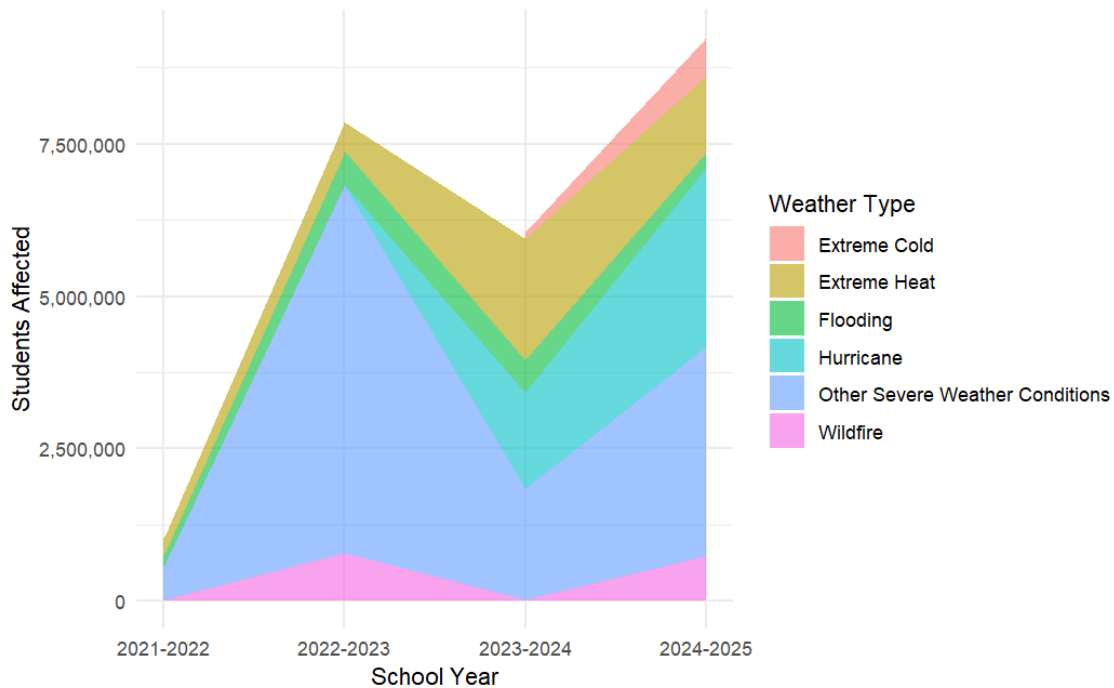
**Figure 10.** Total number of weather-induced prolonged unplanned public-school closures from 2011 to 2019 by weather event type



Sources: CDC Prolonged Unplanned School Closures, USA (2011-2019).

Note: A prolonged unplanned school closure is defined as a school closure lasting  $\geq 5$  school days, excluding any scheduled days off. Fire includes incidents of type 'Wildfire'. Flood includes incidents of type 'Flood (river/creek)'. Storm includes incidents of type 'Hurricane', 'Rain (heavy/severe/tropical storms)'. Winter Weather includes incidents of type 'Ice/Snow'.

**Figure 11.** Number of students affected by weather type



Sources: UndauntedK12.

Note: Includes data for both public and private schools, capturing various types of disruptions, including school cancellations, school disruptions, extracurricular cancellations, and extracurricular disruptions. Data represent both individual schools and school districts. Early data collection efforts for the 2021-2022 school year may be incomplete. Other Severe Weather Conditions refer to closures caused by tornadoes, heavy precipitation, high winds, or any combination of these factors.

For instance, in 2008, Hurricane Ike closed 55 Texas school districts (623 schools) for 10 or more school days (Esnard et al., 2018). Hurricane Harvey caused over 3,000 unplanned school closures across four states (Jackson & Ahmed, 2020). On the West Coast, wildfires are largely responsible for weather-induced school closures. Between the 2002-03 and 2018-19 school years, wildfires closed schools for 21,442 days in California (Miller & Hui, 2022).

Chronic exposure to extreme heat is also straining school buildings and operations, leading to closures and early dismissals (Peetz, 2024). In August 2024, 63 schools in Philadelphia with inadequate air conditioning were required to close early on extremely hot days,

marking the third consecutive year of closures due to heat (Hunt, 2024). Additionally, high heat days often cause schools to move recess indoors given the elevated risks to students of heat illness and contact burns from playground surfaces (Kiros, 2024; Phillips, 2024). Green Schoolyards America found that California schoolyards have a median tree canopy of just 6.4%; increasing coverage to 30% would add shade, sequester 40 million pounds of CO<sub>2</sub>, and capture 405 million gallons of stormwater annually (Green Schoolyards America, 2024). Schools have also had to cancel outdoor activities or close due to poor air quality from fires, as wildfire smoke contains high concentrations of fine particulate matter (PM<sub>2.5</sub>) (Venegas Marin et al., 2024).

Although we have ample evidence that climate change's impacts on environmental pressures and extreme weather create operational challenges for schools, we lack consistent data on the consequences of these events. More formal financial accounting of the immediate and persistent costs caused by climate change would help policymakers understand the effects of climate change on district budgets and evaluate solutions. Collecting these data in a systematic way will also serve as an important benchmark to track trends and changes over time.

### **Dimension #3: The Effect of Environmental Pressures on Students and Teachers**

Climate change and the environmental pressures it creates affect students' abilities to learn through direct and indirect pathways (Prentice et al., 2024). Exposure to environmental toxins early in life, even in utero, has clear negative consequences for students' cognitive development. Extreme weather events can disrupt learning and have adverse health, socio-emotional, and economic effects on students and teachers outside of school that spill over into the classroom. There is also a compelling body of evidence documenting the consequences of natural disasters, extreme heat, and air pollution on academic performance and persistence.

#### Early Childhood Development

Young children are often impacted “first and worst” by the stressors of climate change (Cuartas et al., 2024). The negative effects of climate change on student cognitive development begin well before the start of formal schooling. Prenatal exposure to pollution, extreme temperatures, and environmental disasters can have lifelong consequences for children’s foundational skills, which influence their readiness and capacity to learn in school (Currie, 2013; Lepeule, 2024; World Health Organization, 2023). Children in Florida whose families lived within two miles of a toxic Superfund site when they were in utero were substantially more likely to repeat a grade and score lower on achievement tests than their siblings conceived after the site was cleaned (Persico & Venator, 2021). Prenatal and postnatal exposure to air pollution has lasting negative effects on foundational cognitive, motor, social-emotional, and behavioral skills (Cuartas et al., 2024). Exposure to disasters can also heighten emotional distress and anxiety among children (Lai & La Greca, 2020; SAMHSA, 2018; Viana et al., 2017). Disruptions to access in early childhood care due to natural disasters can further impact children's emotional and developmental well-being (Lai & La Greca, 2020). For example, many Early Head Start and Head Start programs have closed temporarily or permanently following an extreme weather disaster (Grindal et al., 2024).

### Student Success in School

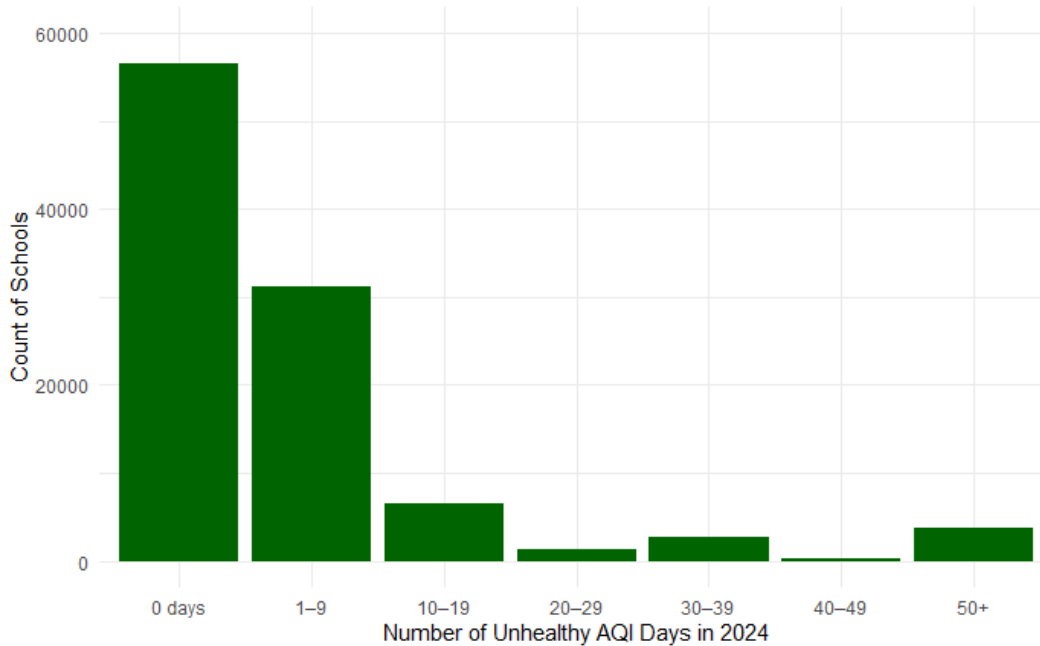
Research suggests that the effects of climate change already directly impact student success in school. A recent meta-analysis highlights the multiple ways in which extreme weather events are detrimental to student achievement and deepen existing educational inequalities (Venegas Marin et al., 2024). Studies that leverage the quasi-random timing of natural disasters document their negative effects on student performance, high school graduation rates, and post-secondary enrollment (Oppen et al., 2023). These negative effects likely operate through multiple

mechanisms including school closures that reduce instructional time, lower attendance, and increased dropouts (Kraft & Novicoff, 2024; Venegas Marin et al., 2024) as well as the negative health, social-emotional, economic impacts described below. Displacement due to natural disasters can also disrupt students' educational trajectories and academic progress. For example, the 2005 Hurricanes Katrina and Rita displaced nearly 26% of Louisiana's 740,000 public school students, with most of these students missing at least 5 weeks of school (Pane et al., 2008). Research shows that these displaced students experienced a sharp decline in achievement the year following the storms (Sacerdote, 2012).

In many states, the rising number of high heat days creates difficult learning conditions that negatively affect students. Numerous studies credibly document how heat causes student cognitive performance to decline and cumulative heat exposure reduces rates of learning and negatively impacts achievement (Graff Zivin et al., 2018; Park, 2022; Park et al., 2020). School buildings and grounds that use heat absorbing materials and lack shade can magnify the effects of hot days. Researchers from The Trust for Public Land found that in 2019, 4.1 million students attended schools in severe heat islands with temperatures 7°F or more above nearby areas (The Trust for Public Land, 2020). The effects of extreme heat are also unevenly distributed. Black and Hispanic students disproportionately experience hot school days: approximately 5% of the racial achievement gap can be attributed to differences in temperature (Park et al., 2020).

Exposure to environmental pollutants such as airborne particulate matter and chemical toxins also has chronic negative effects on students' success in school. Figure 12 demonstrates that over 14,000 public schools were exposed to two weeks or more of unhealthy air quality in 2024, with approximately 4,000 experiencing more than 50 days of poor air quality.

**Figure 12. School exposure to unhealthy air in 2024**



Sources: Environmental Protection Agency (Annual AQI by County 2024), National Center for Education Statistics Public School Locations 2023-24.

Note: Schools were matched to the counties in which they are located. Days with an Air Quality Index (AQI) over 100 were classified as unhealthy.

Poor air quality can result from the release of pollutants like industrial toxins, automotive exhaust, or wildfire smoke, which contain high concentrations of PM<sub>2.5</sub>. Research documents the direct negative effects of air pollution on student attendance, access to outdoor recess, and learning (Gartland et al., 2022; Gilraine, 2020; Gilraine & Zheng, 2024). For example, Chung et al., (2025) use detailed daily attendance records in a large district in California to show that a 10 microgram per cubic meter ( $\mu\text{g}/\text{m}^3$ ) increase in PM<sub>2.5</sub> leads to a 5.7% rise in full-day student absences. Natural experiments created by changing wind patterns and the timing of pollution site openings and closings find that traffic pollution from highways and chemical toxins produced by industrial plants lower student achievement, increase behavioral incidents, and increase absences (Heissel et al., 2022; Persico & Venator, 2021). Research also affirms that interventions to reduce exposure to air pollution benefit students. Replacing older diesel school buses with newer, lower-emitting buses increases student attendance, likely by decreasing health risks such as asthma

(Pedde et al., 2023). Improvements in school HVAC systems also reduce student absence and suspension and improve achievement (Biasi et al., 2025; Sorensen et al., 2024).

### Health, Social-Emotional, and Economic Impacts on Students

Climate change also affects school-aged children's abilities to succeed in school through impacts on their health, social-emotional wellbeing, and the economic security of their families. Effects on student health arise from the acute and prolonged consequences of our changing climate. Exposure to extreme heat, the leading weather-related cause of death in the United States, is associated with cardiovascular and respiratory diseases, long-term neurological issues, and childhood asthma (Ebi & Hess, 2020; Rocque et al., 2021). Air pollution and poor air quality also increase the chances of students developing asthma and other respiratory diseases, dermatitis, and even cancer (EPA, 2023). For instance, elevated concentrations of particulate matter less than 10 micrometers in diameter (PM10) have been associated with increased asthma-related health impacts among children, including higher emergency room visits and hospitalizations in Phoenix, Arizona, and greater use of asthma medication in Anchorage, Alaska (Dimitrova et al., 2012; Gordian & Choudhury, 2003).

Climate change also harms students' mental and emotional health. A global survey found that the majority of U.S. respondents aged 16 to 25 felt anxious, sad, and afraid about climate change (Hickman et al., 2021). Research has also shown that natural disasters often lead to a rise in post-traumatic stress disorder, depression, anxiety, substance abuse, and domestic violence among adults that can have direct negative consequences for children (Clayton, 2020; Wray, 2022). Students often express stress over prolonged housing instability, food insecurity, loss of employment for their parents, and social isolation as a result of natural disasters (GAO, 2022).

Wray (2022) underscores that ecological anxiety is not only common, but that it is rational and a sign of care for the state of the world.

Climate change and the impacts of natural disasters also have immediate economic consequences for students and their families. School closures caused by natural disasters can erode household income as adults need to stay home from work more frequently due to lack of childcare (Zheteyeva et al., 2017). Following the 2015 flash flood in Richland County, South Carolina, households lost an average of \$437 in earnings due to school closures (Gall et al., 2022). Climate change, with its associated increases in natural disasters and extreme heat, can significantly disrupt work, particularly for parents in the construction and agriculture industries where workers often face greater risk of job losses (Kendle et al., 2023; Sánchez, 2024). Job disruptions can have negative spillover effects on students; evidence suggests that job losses and parental unemployment are linked to decreases in student performance and increases in grade repetition (Ananat et al., 2011; Stevens & Schaller, 2009).

### Impacts on Teachers and Staff

Although it receives for less attention, recent research has begun to illustrate how climate change also negatively impacts the ability of teachers and staff to do their jobs. Teachers frequently endure similar hardships as their students during natural disasters. For instance, approximately 80% of teachers in Mississippi affected by Hurricane Katrina lost their homes (Madrid & Grant, 2008), and around 80 educators in Maui experienced housing insecurity following the Lahaina wildfires in 2023 (Tagami, 2023). Providing social-emotional support to students in the wake of an extreme weather event can also increase the risk of teacher burnout and emotional fatigue, especially as teachers may be coping with their own personal losses (Cannon et al., 2023). Environmental pressures can also affect teachers' health and attendance. A

recent study found that a 10  $\mu\text{g}/\text{m}^3$  increase in daily PM<sub>2.5</sub> levels increased teacher absences due to illness by 13.1% (Chung et al., 2025). Additionally, damage to school buildings and facilities disrupts teachers' abilities to work effectively. Without access to classrooms, teaching materials, and technology, teachers must adjust routines and ad-lib solutions (Hebebcı, 2023).

Ample evidence documents the negative effects of climate change and pollution on students and teachers. New research might build on the existing body of literature by exploring how emergency response systems and remote learning plans can reduce the amount of lost instructional time students experience. We also know little about efforts to better support teachers during these crises so they can continue to be effective educators for their students.

#### **Dimension #4: Teaching and Learning about Climate Change**

Teaching students about the natural world and the ways humans are impacting it has an important role at every stage of preK-12 education. From an early age, schools can help expose students to nature and develop their appreciation for the role humans play in their environment through nature-based education and an introduction to Indigenous ways of knowing. Schools can also teach children about the core science underlying climate change. In later years, schools can prepare students to launch careers that contribute to advancing climate solutions.

##### Nature-Based Education and Indigenous Ways of Knowing

Education that takes place in outdoor settings helps develop students' relationships with nature and the environment. The integration of outdoor education into formal public schooling has over a century-long history in the United States (Hengtgen, 2019). More recently, the number of nature-based pre-schools and kindergartens has grown rapidly, increasing from just several dozen to over 800 in the last fifteen years (NAAEE, 2023). In some high schools, education in natural settings is focused on field work for science classes. In others, outdoor education

experiences center character development and leadership skills. Students report that these excursions in nature are often among the most memorable experiences they have in school (Dillon et al., 2016). They can also be central to addressing children's disconnection with nature, especially among those living in urban settings, and can reduce fears and phobias of the natural world. Systematic literature reviews of case studies and pre/post measures of change suggest that such experiences can have physical, psychological, and academic benefits for students (Kuo et al., 2019; Mann et al., 2022; Zylstra et al., 2014).

Nature-based education can also play a key role in exposing students to more traditional ways of relating to the natural world, reducing the psychological distance between humans and the environment (Bang et al., 2007; Kimmerer, 2013). Modern culture positions humans as *apart from* nature. In contrast, many Indigenous cultures regard humans as *a part of* nature (Medin & Bang, 2014). Traditional ecological knowledge also offers scientific insights gained across generations of observing the interconnected nature of flora and fauna in specific ecosystems (Kimmerer, 2013). Indigenous peoples' traditional knowledge of sustaining ecologically balanced relationships with their local environments can inform a range of subjects taught in schools. For example, Albuquerque Public Schools integrates outdoor education and cultural learnings from local Indigenous traditions into the standard curriculum (Kamenetz, 2023). By emphasizing relational ties to the environment, nature-based and Indigenous-informed education can strengthen students' sense of responsibility and support for sustainable ways of living.

### Teaching Climate and Environmental Sciences

What, when, and how schools teach about climate science has important consequences for students' beliefs, career choices, and preparation to address the challenges of climate change. Almost all state science standards draw on either the *Framework for K-12 Science Education*

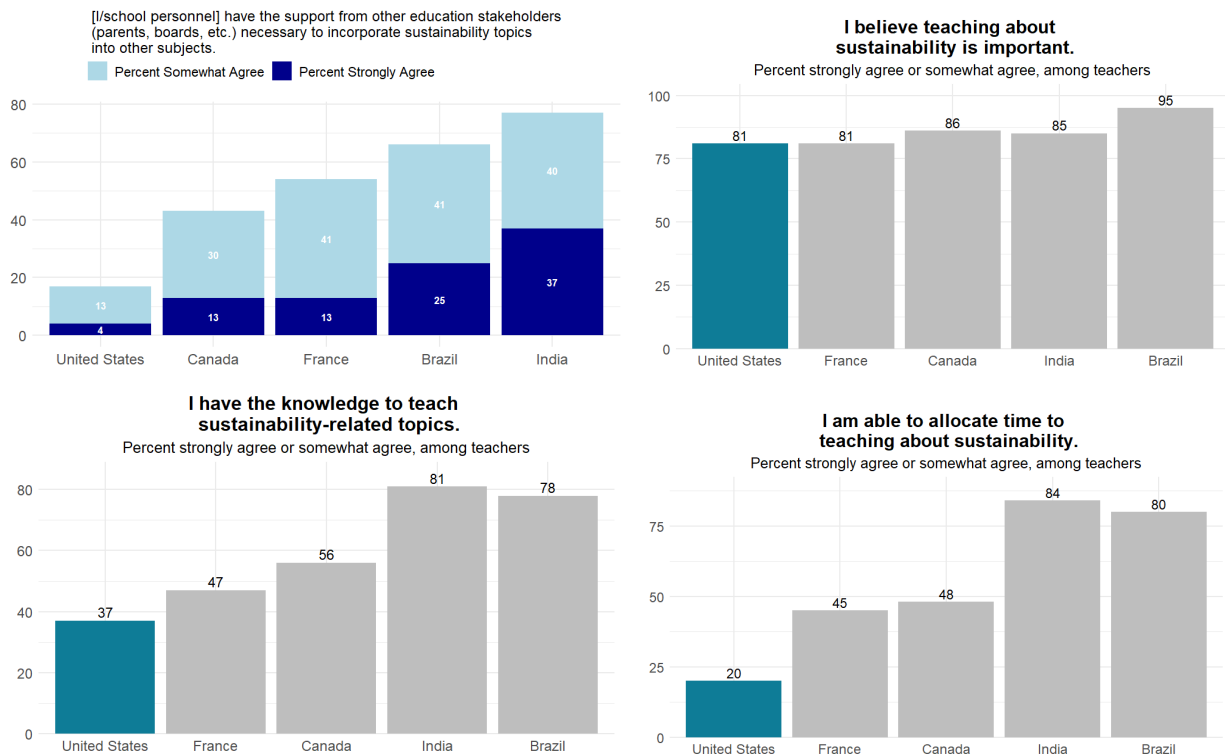
*Standards* or the *Next Generation Science Standards* (NGSS), the latter of which explicitly integrates climate change. Despite widespread adoption and adaptation of modern learning standards, the National Center for Science Education's (NCSE) 2020 review of state science standards graded 19 states as earning a C- or lower on reflecting climate change as a real phenomenon (NCSE & TFNEF, 2020). In five states (AL, GA, MA, SC, and TX), climate change was only covered in optional high school classes as of 2020 (The Aspen Institute, 2020).

Some states have integrated climate change into additional subject standards. A review by the Aspen Institute in 2020 found that 17 states' social studies standards explicitly included climate change, often in relation to its growing political and economic consequences (The Aspen Institute, 2020). Several non-profit organizations are also creating and curating resources for educators to teach climate change across a range of subjects (Earth Friends, n.d.; SubjectToClimate, n.d.). For example, elementary classroom teachers have begun to incorporate climate change as part of elementary literacy instruction (Woodard & Schutz, 2024). Climate change is most commonly taught in high school earth science and biology classes as well as in middle school sciences with a focus on the greenhouse effect, carbon cycle, and sea level change (National Center for Science Education, 2016). However, thirty five percent of middle and high school science teacher respondents to a 2014-15 survey by NCSE reported spending equal time on perspectives that "raise doubts that humans are causing climate change," despite the overwhelming scientific consensus for this fact (Plutzer et al., 2024).

Research suggests U.S. teachers often do not feel prepared or supported to deliver effective instruction on climate change. Compared to peers in Canada, France, India, and Brazil, U.S. K-12 teachers are far less likely to report having the time, knowledge, instructional

materials, and professional support to teach topics related to sustainability (see Figure 13) (Smithsonian Science Education Center, 2023).

**Figure 13.** Teachers' views of the support they receive to incorporate sustainability topics



Sources: Smithsonian Science Education Center, 2023.

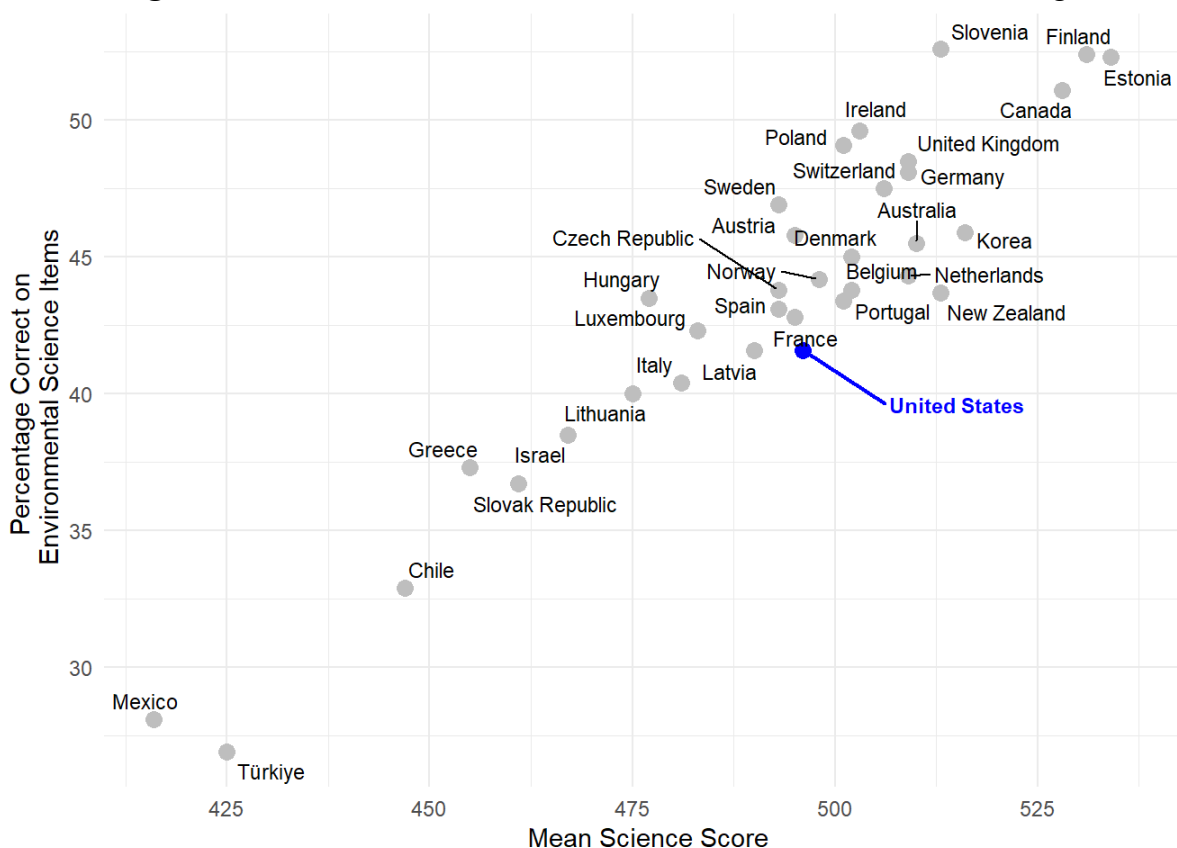
Note: This graph replicates a visualization from the Smithsonian Science Education Center.

Teacher preparation programs do little to prepare preservice teachers for the challenges of teaching about climate change (Beach, 2023). More than half of K-12 teachers surveyed by NCSE received no instruction on climate change in their training (Plutzer et al., 2016). This may explain why 17% of teachers in a national survey reported that they did not teach about climate change because they did not know enough about it (Kamenetz, 2019). Analyses of widely adopted textbooks for middle school science, high school history, and high school biology find that these resources often dedicate few if any passages to climate change and frame both its existence and human contribution as uncertain (Ansari & Landin, 2022; D'Apice & Bromley, 2023; Román & Busch, 2016).

Teaching about climate change also creates pedagogical challenges that are distinct from most traditional subjects (Baker & Gehlbach, 2022). Skepticism towards academic research and the outright denial of scientific evidence have both grown in recent years (Sinatra & Hofer, 2021). Presenting climate change as human-caused in classrooms can cause some students to feel as though their teachers are contradicting the viewpoints expressed at home given 42% of American adults at least question whether humans are playing a role in climate change (Yale Program on Climate Change Communication, 2023). Beyond the perspectives of parents, teachers also need to be prepared for the emotional impact that teaching about climate change can have on students. More than half of U.S. teenagers report feeling afraid when asked how climate change makes them feel (Hickman et al., 2021).

The patchwork of diverse curriculum standards and instructional practices across U.S. schools lead to meaningful blind spots in students' knowledge about climate change. A 2019 survey by the Washington Post and the Kaiser Family Foundation found that 46% of U.S. teenagers reported learning "a little" or "nothing" about the causes of climate change in school, and 54% reported learning a little or nothing about ways to reduce the effects of climate change (The Washington Post, 2019). Results from the 2015 PISA science exam illustrate that American 15-year olds' understanding of environmental science ranks below that of 24 other countries, as shown in Figure 14. In fact, American students' average scores across 11 test items assessing environmental science is far lower than countries that have similar *overall* science scores, suggesting environmental science is a particular weakness of U.S. science education (OECD, 2022). Multiple surveys suggest that many teenagers hold incorrect beliefs about the primary contributors to global warming, including the sun getting hotter and volcanic eruptions (The Washington Post, 2019; Will & Prothero, 2022).

**Figure 14.** PISA 2015 science scores vs. environmental science knowledge

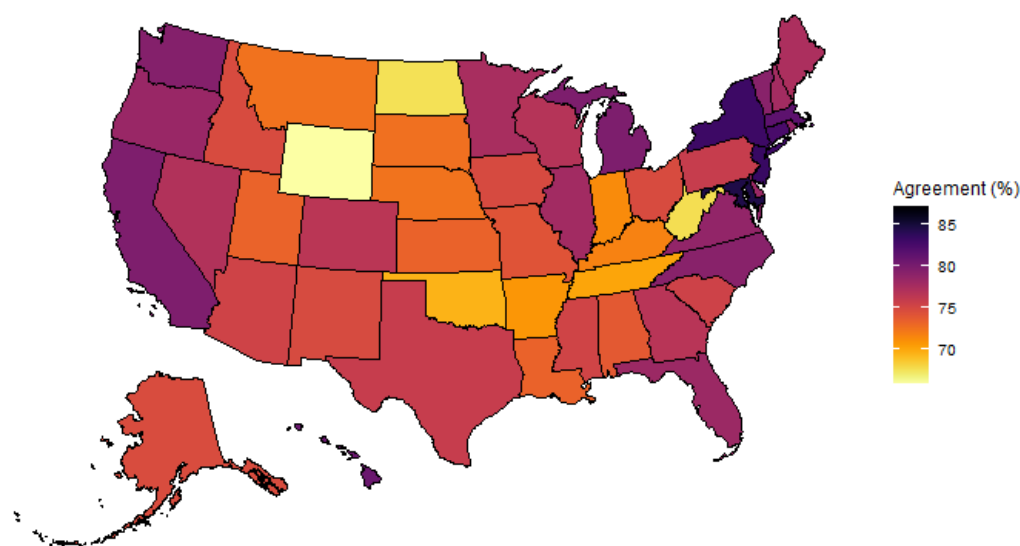


Sources: The Organization for Economic Cooperation and Development (OECD), 2022.

Note: Scores on the x-axis represent average national performance on the 2015 PISA science exam. The y-axis presents the average percent of correct responses on a subsample of science questions about environmental science.

Surveys suggest that there is both widespread support and a major need for teaching more about climate change in preK-12 schools in developmentally appropriate ways. For example, a 2019 NPR/Ipsos poll found that 80% of parents think climate change should be taught in schools. A 2024 survey by the Yale Program on Climate Change Communication found that 76% of American adults agree that schools should teach about global warming. Support varies considerably across states, ranging from 87% in the District of Columbia to 66% in Wyoming (see Figure 15), suggesting a need to tailor approaches to local contexts.

**Figure 15.** Percent of American adults agreeing that schools should teach about global warming



Sources: Yale Program on Climate Change Communication, 2024.

Note: This graph replicates a visualization from the Yale Program on Climate Change Communication. See Appendix Table A1 for state-specific reported values of respondent agreement.

### Job Training and Innovation

Beyond teaching about the science of climate change and what our society can do about it, schools also prepare students with the critical thinking and technical skills required for jobs that advance sustainable practices (Rosen, 2023). Over 11 million high school students participate in Career and Technical Education (CTE) programs – courses to develop skills for a wide range of occupations (Advance CTE, 2023). At least 29 states offer CTE programming related to jobs in the green economy (K12 Climate Action, 2020). These jobs include sustainable construction and building practices, renewable energy, and environmentally responsible land stewardship, agriculture, and aquaculture. Many programs provide dual enrollment opportunities at community colleges, offer industry-recognized credentials, and support transitions to career apprenticeship programs. Career-focused pathways can help build the workforce necessary for transitioning to more sustainable infrastructure and industry.

Adapting to the pressures that environmental degradation is placing on society will require innovative thinking. Schools play an important role in preparing students to pursue higher education and become the next generation of innovators (Biasi et al., 2020). For example, Arold (2022) finds that exposure to the science of evolution in school increases the probability of working in the life sciences by 23%, suggesting that teaching about climate or earth sciences might also increase the pipeline of students who enter STEM fields.

Case studies and descriptive evidence provide an informative characterization of the state of climate education and the support teachers need to deliver effective instruction about climate change across the curriculum. However, schools have little evidence on efficacy of different instructional materials and professional development programs to support climate education. We also collect little formal data on students' knowledge about the causes, consequences, and possible solutions to climate change. More direct research on the efficacy of CTE programs focused on the clean economy would better inform both federal and state policy efforts to strengthen and scale career pathways in the sustainable economy.

#### **Dimension #5: Schools' Broader Influences on Students, Families, and Communities**

Schools can have a wide-reaching influence on communities through their direct impacts on students' knowledge and beliefs, through students' interactions with their friends and families, and through community programming and the use of school buildings.

Education shapes the knowledge, beliefs, and attitudes students have about climate change and conservation. In the United States, adults who have completed at least some higher education are more likely to be concerned about climate change (Semenza et al., 2008). New research by Angrist et al. (2024) leverages variation in educational attainment due to compulsory schooling laws to show that, on average, more education causes students to be more likely to

adopt pro-climate beliefs, behaviors, and policy positions in a large sample of European adults. Schools that directly teach about the environment have even larger effects on students' orientations toward climate change. A substantial body of research reviewed by Van De Wetering et al., (2022) suggests that environmental education not only impacts what students know and believe about the environment but also their actions and intentions to sustain the planet.

The impacts of preparing students with the curiosity, critical thinking skills, and content knowledge to engage with the realities of our changing climate can also ripple across the larger community. Multiple randomized control trials document how students in environmental education programs share knowledge with peers and influence parents' attitudes and behaviors (Alix-García & Knittel, 2025; Bhattacharya et al., 2024; Lawson et al., 2019; Wang et al., 2022). Inter-generational learning is particularly promising because young people are less likely to hold political ideologies that shape how they interpret scientific evidence (Peterson et al., 2019).

In addition to educating children, schools are also cornerstone social institutions. At least 83% of U.S. families live within 2 miles of a public school (Chingos & Blagg, 2017). Schools serve as centers for afterschool care, sports and recreation, community events, and voting among many other social functions. Schools are often dedicated emergency shelters during extreme weather events (C. R. Davis et al., 2021; Dela Cruz, 2017; Ilumin & Oreta, 2018). This central, multifaceted role in society means that even if adults do not have school-aged children, they often interact with the public schools in their community.

Research on the general influence of schools on their communities and their specific impacts on communities' beliefs and actions related to climate change are among the least studied aspects of education and climate change. We stand to learn much more about how the

cultural salience of schools makes them a mainstay institution for shaping their communities through school-based programming and as gathering places that facilitate the diffusion of ideas.

### **Discussion & Conclusion**

The challenges created by climate change are on an unprecedented scale for humanity. It will require the commitment and energy of individuals, institutions, and industries to curb global warming and create a sustainable balance between human civilization and the planet. Education systems have a critical role to play in these efforts. Today, climate change is forcing schools to adapt by necessity. Rising temperatures and sea levels, extreme weather events, and pollution reduce time spent in school, undercut student wellbeing and achievement, and deepen existing inequalities. Climate change also strains school budgets as they face the rising costs of property insurance, building repairs and retrofitting, and instability in student enrollment all due to extreme weather. Adapting to and addressing these challenges is essential to ensure that all students have equal access to safe and effective learning environments.

In the United States, and across the world, schools are among the largest systems of public infrastructure and are social institutions with substantial influence. Schools have great potential to reduce their environmental footprint through energy conservation, electrification, increasing tree coverage, and reducing food waste. District investments in sustainable energy and infrastructure could influence broader market trends. When schools model as environmental stewardship, they have the potential to have ripple effects throughout their communities.

Schools can also inspire hope and a sense of agency in students by teaching about both the underlying science of climate change as well as pathways to sustain a healthy planet. This presents an opportunity to make school more engaging by addressing a topic that is increasingly relevant to students' lived experiences and the real-world challenges of our time. Schools can

prepare students with the applied knowledge and skills to innovate and fill important positions in sectors across the economy as they transition to clean energy, adopt sustainable practices, and develop new climate solutions. Schools can also help students develop a deeper understanding and connection with the natural world and sow the seeds of greater social awareness through the influence children have on their parents and communities.

### **The Critical Role of Research**

Researchers can support these ongoing initiatives by building the evidence necessary to iteratively refine and scale effective policies and programs. Identifying promising policies will require a deeper understanding of which efforts to make schools more resilient and sustainable might also reduce operating costs, make schools more welcoming environments, and support student success. It will also require evidence on how best to integrate climate education into existing lessons and schedules in ways that are 1) compatible with local priorities and perspectives, and 2) synergistic rather than additive given the large demands already placed on educators. Scholars across disciplines have already begun this important work, but the field is only just emerging and major gaps in our knowledge remain.

We identify five broad dimensions which hold promise for expanded scholarly focus on topics at the intersection of education and climate change. In Table 1, we summarize these themes and provide illustrative examples of research questions for each. We expect that research at the intersection of education and climate change will often incorporate multiple dimensions in crosscutting ways. For example, scholars have studied how school gardens that provide fresh produce for school meals have also lowered carbon emissions of food procurement, provided a natural setting for outdoor education, and increased fiber and vegetable consumption among students (J. N. Davis et al., 2011, 2021; Gardner et al., 2023).

**Table 1.** Thematic Dimensions of Education Systems and Climate Change

<b>Dimension</b>	<b>Subdomains and Elements</b>	<b>Example Research Questions</b>
Environmental impacts of the U.S. PreK-12 education system	<ul style="list-style-type: none"> <li>- Facility emissions and energy sources</li> <li>- Transportation emissions</li> <li>- School meal programs</li> <li>- Water consumption</li> </ul>	<ul style="list-style-type: none"> <li>- How do school operations and infrastructure contribute to carbon emissions?</li> <li>- What programs and policies reduce education system emissions?</li> <li>- How do sustainable investments impact school operating costs?</li> </ul>
Climate change impacts on school infrastructure, budgets, and operations	<ul style="list-style-type: none"> <li>- Physical infrastructure damage and destruction</li> <li>- Financial consequences of climate change for schools</li> <li>- School operations disruptions (closures, transportation disruption, staff shortages)</li> </ul>	<ul style="list-style-type: none"> <li>- In what ways is school infrastructure susceptible to the risks posed by climate change?</li> <li>- What schools are most vulnerable to the impacts of the chronic and acute effects of climate change?</li> <li>- What are the financial consequences of extreme weather on schools and how are they distributed?</li> </ul>
Effects of environmental pressures on students and teachers	<ul style="list-style-type: none"> <li>- Early childhood development</li> <li>- Student success in school (heat, disruptions from closures)</li> <li>- Health, social-emotional, and economic impacts on students (exposure to toxins, climate anxiety, disaster impacts on home life)</li> <li>- Teachers and staff stressors (disaster impacts, access to resources)</li> </ul>	<ul style="list-style-type: none"> <li>- How do extreme weather events disrupt student learning and affect long-term outcomes?</li> <li>- What policies and interventions mitigate the detrimental impacts of heat and poor air quality on students?</li> <li>- How does developing emergency response systems or remote learning plans reduce lost instructional time?</li> </ul>
Teaching and learning about climate change	<ul style="list-style-type: none"> <li>- Nature-based education and indigenous ways of knowing</li> <li>- Teaching climate and environmental sciences (learning standards, teacher preparation)</li> <li>- Job training and innovation (CTE programming, advanced science course taking)</li> </ul>	<ul style="list-style-type: none"> <li>- What do schools teach about climate science?</li> <li>- How does science education affect students' beliefs, career choices, and preparedness to address climate change challenges?</li> <li>- How can teacher preparation programming help teachers effectively integrate climate change across the curriculum?</li> <li>- What is the landscape and impacts of CTE programs that prepare students for jobs that advance sustainable practices?</li> </ul>
Schools' broader influences on students, families, and communities	<ul style="list-style-type: none"> <li>- Education's impact on social attitudes and beliefs</li> <li>- Spillover from students to peers, parents, and communities</li> <li>- Schools as environmental stewards in their community</li> </ul>	<ul style="list-style-type: none"> <li>- What are the spillover effects of schools as social institutions and community hubs on community beliefs and climate change resilience?</li> <li>- How does student access to climate science education impact family beliefs and behaviors?</li> </ul>

This research will require substantial work to expand data collection on the part of schools, districts, states and the federal government. We currently lack systematic administrative data on a range of key measures including: 1) the condition of school infrastructure, 2) carbon benchmarking and lifecycle assessment of schools, 3) the cumulative costs of climate change on district budgets, 4) district and state policies related to education and climate change, 5) the diffusion of climate education across schools, 6) assessments of students' climate knowledge and perspectives on climate change, and 7) the diverse ways school buildings serve communities.

A range of disciplinary and methodological approaches will also be necessary to advance these lines of research. We particularly emphasize the importance of applied research that aims to directly inform education policy and practice. Education policy organizations can play an important role in catalyzing this work by creating scholarly communities and forums that facilitate interdisciplinary collaboration in partnerships with policymakers, schools, and industry. We have much to learn about the complex relationship between education systems and climate change. The urgency to advance this research grows with every uptick in global temperatures and rise in sea levels. Let's get to work.

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## Appendix

**Appendix Table A1.** Environmental and Educational Indicators by State

<b>State</b>	<b>Public K-12 Annual Building Carbon Emissions (Metric Tons per Sq Ft)</b>	<b>Percentage of Schools with Solar</b>	<b>Committed Electric School Buses per 10,000 Students</b>	<b>Schools in High- Risk Flood Zones</b>	<b>Percentage of Adults Agreeing Schools Should Teach Global Warming</b>
Alabama	4,709	0.17	0.94	13	73.86
Alaska	5,536	0.74	0.15	0	74.74
Arizona	5,056	14.17	1.66	51	75.34
Arkansas	6,521	4.10	1.88	22	70.80
California	2,626	21.87	5.33	338	79.72
Colorado	7,184	7.39	1.66	12	76.56
Connecticut	3,747	26.33	4.12	11	82.44
Delaware	6,539	3.53	0.35	1	78.26
District of Columbia	8,026	23.36	5.39	0	87.01
Florida	5,379	4.46	1.63	425	78.22
Georgia	5,310	1.66	1.95	10	76.66
Hawaii	6,962	29.43	1.36	13	80.75
Idaho	2,532	3.74	0.73	9	74.76
Illinois	4,876	10.52	3.30	42	77.84
Indiana	8,555	5.34	1.01	21	71.32
Iowa	6,632	3.09	1.18	10	74.84
Kansas	5,958	0.85	1.32	6	73.34
Kentucky	9,983	2.03	1.58	32	71.76
Louisiana	6,237	0.42	4.00	134	73.34

State	Public K-12 Annual Building Carbon Emissions (Metric Tons per Sq Ft)	Percentage of Schools with Solar	Committed Electric School Buses per 10,000 Students	Schools in High- Risk Flood Zones	Percentage of Adults Agreeing Schools Should Teach Global Warming
Maine	3,352	5.66	4.52	2	77.32
Maryland	4,580	10.13	4.93	5	84.46
Massachusetts	4,728	13.05	4.74	25	81.42
Michigan	6,186	1.99	2.21	17	79.76
Minnesota	6,134	6.07	1.16	3	77.49
Mississippi	4,971	0.99	3.78	39	75.31
Missouri	9,623	3.50	2.57	16	74.24
Montana	7,049	4.99	5.43	9	72.52
Nebraska	8,489	0.55	0.70	19	72.46
Nevada	4,719	19.06	1.19	22	77.06
New Hampshire	2,946	6.42	7.02	3	77.80
New Jersey	4,547	20.67	2.20	72	83.30
New Mexico	6,966	5.35	1.09	41	74.84
New York	3,997	5.36	3.02	79	83.02
North Carolina	4,900	3.17	1.70	21	79.18
North Dakota	9,194	0.17	1.51	6	67.62
Ohio	6,866	2.29	0.98	33	74.76
Oklahoma	4,492	1.29	1.97	18	69.55
Oregon	2,425	5.06	4.31	20	78.33
Pennsylvania	5,060	2.53	2.72	26	75.85

<b>State</b>	<b>Public K-12 Annual Building Carbon Emissions (Metric Tons per Sq Ft)</b>	<b>Percentage of Schools with Solar</b>	<b>Committed Electric School Buses per 10,000 Students</b>	<b>Schools in High- Risk Flood Zones</b>	<b>Percentage of Adults Agreeing Schools Should Teach Global Warming</b>
Rhode Island	4,709	6.20	5.80	3	78.67
South Carolina	3,632	4.08	2.46	19	75.44
South Dakota	3,883	0.00	0.57	7	72.61
Tennessee	4,431	2.73	0.86	17	70.17
Texas	5,885	1.27	0.77	253	75.84
Utah	8,372	9.92	0.52	6	73.31
Vermont	2,294	21.50	4.73	2	79.21
Virginia	4,306	6.38	3.06	25	78.69
Washington	2,112	3.84	2.05	40	79.42
West Virginia	10,962	2.04	4.09	57	67.73
Wisconsin	6,802	9.59	1.73	5	76.81
Wyoming	10,382	1.28	0.00	4	65.97

Sources: New Buildings Institute (2021); Generation180; National Center for Education Statistics; World Resources Institute; FEMA National Flood Hazard Layer; Yale Program on Climate Change Communication (2024).