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"The Need for Resilience: Preparing American's Transportation Infrastructure for Climate Change"

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Introduction

I am a senior climate scientist at the Union of Concerned Scientists. I appreciate the opportunity to provide testimony as you examine the intersection of climate change and transportation infrastructure, as my research has shown that road and rail systems along our coasts are at risk of chronic high tide flooding in the coming decades as sea level rises.

Climate Impacts on Infrastructure

Our nation's infrastructure is already in a precarious state, consistently earning a near-failing grade of D-plus from the American Society of Civil Engineers (ASCE)[1]. Much of our infrastructure was built assuming past climate and usage patterns, with some margin of safety, which has led the ASCE to estimate that there is $1.2 trillion gap between our current transportation infrastructure and our actual needs[2].

Now climate change is adding an extra layer of risk.

The impacts of climate change are already upon us—in the form of longer wildfire seasons, stronger storms, worsening droughts, and flooding exacerbated by rising seas and heavy precipitation.

Climate-related extreme events are already exposing vulnerabilities in our infrastructure, and growing development in high-risk areas increases the potential damage. The number of billion-dollar weather and climate-related disasters is on the rise: compared to the long-term average, each of the past three years has produced more than twice the number of billion-dollar disasters in the US[3].

[1] https://www.infrastructurereportcard.org/

[2] American Society of Civil Engineers (ASCE). 2017. 2017 Infrastructure Report Card: A Comprehensive Assessment of America's Infrastructure. American Society of Civil Engineers, Washington, DC, 110 pp

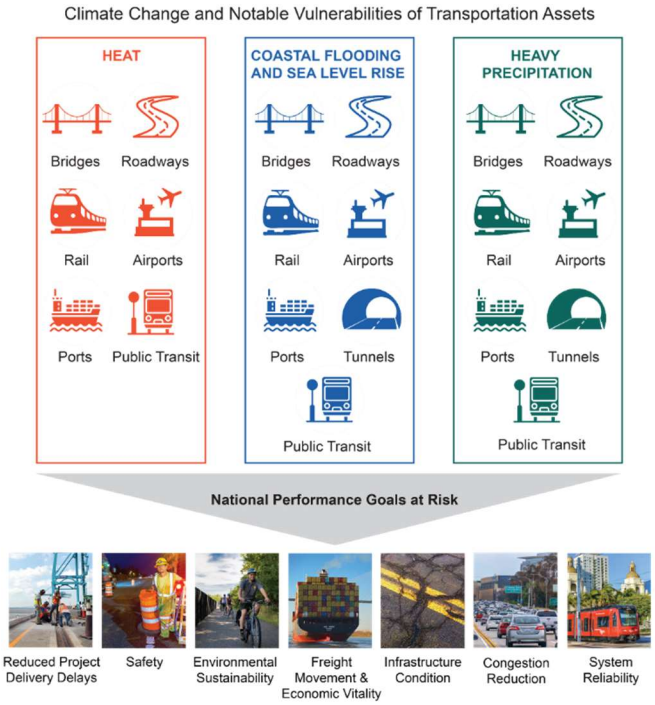
[3] https://www.climate.gov/news-features/blogs/beyond-data/2018s-billion-dollar-disasters-context

As the most recent National Climate Assessment report shows, without strong action to decrease our global warming emissions and adapt to unavoidable impacts, climate change could cost some U.S. economic sectors more than $100 billion annually by late century, surpassing the gross domestic product of many U.S. states[4].

We rely on our roads, rails, and airplanes for safe, reliable transportation, and they serve as a backbone for our country's economy. As our population grows in the coming decades, we will be relying even more heavily on our transportation infrastructure[5]. Infrastructure is typically designed to last 50 to 100 years. New infrastructure projects or improvements must therefore account for future usage increases as well as changes in the environment that could affect reliability or capacity[6].

Climate change is making extreme weather events more frequent and more severe, which amplifies the economic damage we're forced to absorb and imposes a steep toll on people's lives. Future climate change will amplify the risks our vulnerable transportation systems already face[7]. The most recent National Climate Assessment highlighted the many ways in which climate change could impact our transportation assets. In this testimony, I will focus on a few of these impacts.

The transportation sector is also the leading contributor to US heat-trapping emissions, and there are many opportunities to transition to a low-carbon transportation infrastructure while making it more resilient.



Source: Fourth National Climate Assessment. https://nca2018.globalchange.gov/chapter/12/

[4] https://nca2018.globalchange.gov/
[5] https://nca2018.globalchange.gov/chapter/12/
[6] https://transportation.house.gov/imo/media/doc/Majority%20SSM%20Climate%20Change.pdf
[7] USGCRP 2018

Sea Level Rise and Coastal Transportation Infrastructure

Union of Concerned Scientists (UCS) research shows that by the end of the century, 2.5 million US coastal homes and commercial properties currently worth more than $1 trillion today could be at risk from chronic flooding worsened by sea level rise. UCS developed an interactive map tool that lets you explore the risk sea level rise poses to homes in your congressional district and provides district-specific fact sheets about those risks[8]. No matter where you live along the coast, chances are that rising seas will begin to reshape your community to one degree or another in the coming decades. Communities wanting to be prepared for the changes to come will need representatives in Congress who will advocate for the research, funding, and policies we need to address sea level rise and coastal flooding head-on.

We also used our chronic flooding data to assess the risks of chronic flooding to Amtrak's Northeast corridor route between Boston and Washington, one of the most heavily travelled rail routes in our nation. Our maps were used in a Bloomberg story on this subject, *Rising Waters Are Drowning Amtrak's Northeast Corridor*[9].

Chronic flooding in the vicinity of Newark Liberty Airport in Newark, NJ, in 2060 (left) and 2100 (right). Chronically flooded areas are defined as flooding 26 times per year or more and are shown in orange. The Amtrak rail line, shown in black, cuts through the area exposed to chronic inundation highlighted by the green oval.

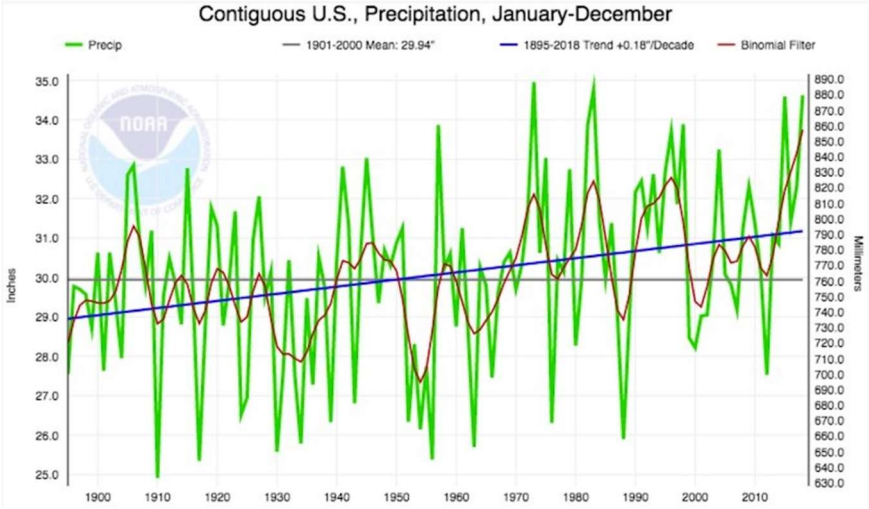
Many parts of the Northeast Corridor rail route are at risk of chronic flooding starting by 2060, including sections near Wilmington, Delaware, and throughout Connecticut, New Jersey, and New York. Current preparation efforts fall far short of these realities.

Impacts of inland flooding on transportation infrastructure

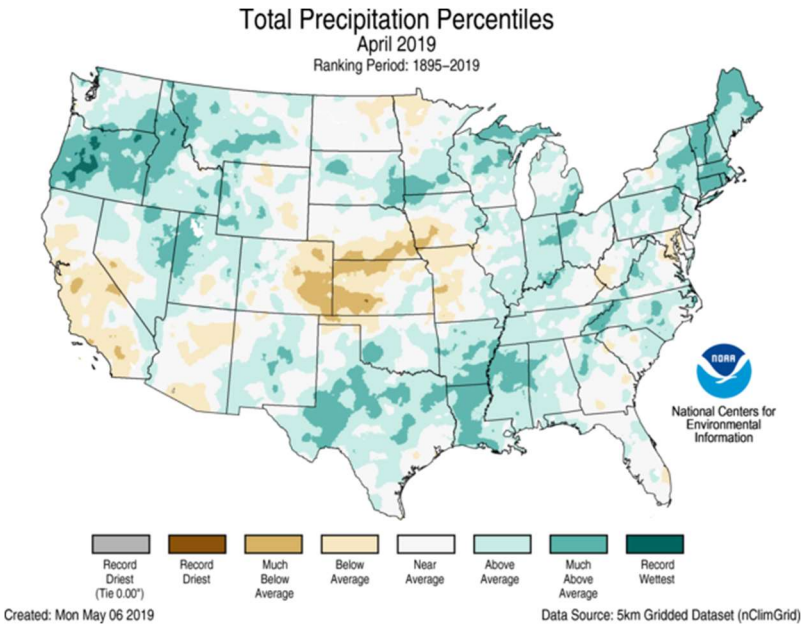
Climate change is changing rainfall patterns, making heavy rain more frequent in many parts of the country[10]. With human alteration of the land—like the engineering of rivers, the destruction of natural

[8] https://arcg.is/1TXHXj
[9] https://www.bloomberg.com/graphics/2018-amtrak-sea-level/
[10] https://www.ucsusa.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf

protective systems, and increased construction on floodplains—many parts of the United States are at greater risk of experiencing destructive and costly floods[11].



While there is considerable variability from year to year and from decade to decade, total annual precipitation for the contiguous US as a whole has increased since 1900. Source: NOAA[12]



April 2019 capped the wettest 12-months on record for the contiguous US. Above normal precipitation and the subsequent flooding across the central US lead to widespread disruption of transportation by road and rail. Source: NOAA[13]

[11] https://www.doi.org/10.1038/nature26145; https://www.propublica.org/article/boomtown-flood-town-text
[12] https://www.wunderground.com/cat6/Wettest-12-Months-US-History?cm_ven=cat6-widget
[13] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201904#us-maps-select

This spring alone has brought extended flooding to many parts of the country, including Louisiana, Texas, the Midwest, and along the Mississippi and Missouri rivers. NOAA data confirm that (at the end of April 2019) the US has just experienced the wettest 12 months on record.

This record-breaking flooding has washed out roads and bridges in many places, sometimes for days on end, making it difficult for people to travel safely to work and school[14]. In Nebraska alone, the flooding caused an estimated $100 million in damage to the state's highway system[15]. Rail lines in Nebraska and Missouri were shut down for weeks[16]. Businesses that rely on safe and reliable transportation have also been affected[17].

A growing body of evidence has linked specific extreme rainfall events to human-caused climate change. The record-breaking rainfall during Hurricane Harvey, for example, was made about three times more likely because of human-caused climate change[18]. Projections of future climate suggest that the frequency and intensity of extreme precipitation events will continue to increase across much of the United States in the coming decades[19]. Models of our transportation infrastructure suggest that as our climate changes, even small increases in the amount of rain falling during a downpour could cause a "systematic malfunction" of our road network[20].

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[14] https://www.washingtonpost.com/nation/2019/05/10/really-genuinely-scary-torrential-rain-houston-strands-cars-leaves-thousands-without-power/?utm_term=.9612e14621c9
https://kfor.com/2019/05/08/odot-several-highways-closed-due-to-flooding-across-the-state/

https://www.wxyz.com/getting-around-metro-detroit/flooding-across-metro-detroit-closes-several-roads-highways

[15] https://dot.nebraska.gov/news-media/nebraska-flood-2019/
[16] https://www.grainnet.com/article/166508/transportation-impacts-of-midwest-flooding
https://www.freightwaves.com/news/railroad/rail-volumes-drop-for-march-30
[17] https://www.mprnews.org/story/2019/04/21/flooding-roundup-communities-weary

[18] van Oldenborgh, G.J., K. van der Wiel, A. Sebastian, R. Singh, J. Arrighi, F. Otto, K. Haustein, S. Li, G. Vecchi, and H. Cullen. 2017a. Attribution of extreme rainfall from Hurricane Harvey, August 2017. Environmental Research Letters 12(12):1–11. doi:10.1088/1748-9326/aa9ef2.
[19] Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner. 2017. Precipitation change in the United States. In Climate science special report: Fourth national climate assessment, volume 1, fourth edition, edited by D.J. Wuebbles, D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock. Washington, DC: US Global Change Research Program, 207–230. doi:10.7930/J0H993CC.
Intergovernmental Panel on Climate Change (IPCC). 2012. Summary for policymakers. In Managing the risks of extreme events and disasters to advance climate change adaptation: Summary for policymakers, edited by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley. Cambridge, UK, 1–19. Online at http://www.ipcc.ch/pdf/special-reports/srex/SREX_FD_SPM_final.pdf
[20] Wang, W., S. Yang, H.E. Stanley, and J. Gao. 2019. Local floods induce large-scale abrupt failures of road networks. *Nature Communications* 10:2114. https://www.nature.com/articles/s41467-019-10063-w

The effects of heat on transportation infrastructure

For much of the contiguous United States, the frequency of extreme heat events has been increasing since the mid-1960s and the number of high temperature records has outpaced the number of low temperature records, particularly since the mid-1980s[21]. Cities throughout the country have experienced not only more frequent extreme heat over the last 60 years, but also more intense and longer-lasting heat waves[22]. As heat-trapping emissions accumulate in the atmosphere, the frequency and intensity of extreme heat events is projected to rise[23].

Extreme heat can affect many types of transportation infrastructure[24]:

- Air travel. High temperatures constrain the allowable weight of aircrafts during takeoff, as we saw when temperatures at the Phoenix airport rose to 119 °F during a 2017 heat wave, prompting the cancellation of 50 flights because the aircraft were above the operable weight limit in such heat (Wang 2017). The cancellation of flights due to heat creates costs for the airline industry and its customers and disrupts both passenger travel and air shipments[25].
- Roads. Depending on the paving materials and the traffic load of a given road, pavement can deteriorate as temperatures rise[26]. The paving material used for a given road is usually based on historical climate conditions, so the occurrence of extreme heat (or precipitation) outside of historical norms can cause pavement to buckle or deform, as occurred in Sacramento, California, during a June 2017 heat wave[27].
- Rail systems. Trains may need to reduce speeds to prevent accidents when the temperature reaches 90 °F[28]. At 110 °F, rails are at increased risk of buckling, which can create dangerous conditions that are costly to repair. While the redundancy in road networks can compensate for the closure of any one road, the same cannot be said for rail networks.

As extreme heat events become more frequent and more severe in response to rising atmospheric concentrations of heat-trapping gases, so too will disruptions to our transportation systems.

Solutions

Climate change and its consequences are already upon us. Given our past carbon emissions, we are committed to a certain amount of sea level rise and future warming. Ignoring the issue will not make it

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[21] Vose R, Easterling D R, Kunkel K and Wehner M 2017 Temperature changes in the United States 36

Abatzoglou J T and Barbero R 2014 Observed and projected changes in absolute temperature records across the contiguous United States - Abatzoglou - 2014 - Geophysical Research Letters - Wiley Online Library Online: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL061441

[22] Habeeb D, Vargo J and Stone B 2015 Rising heat wave trends in large US cities *Nat. Hazards* **76** 1651–65

[23] Projection data can be explored using the US Climate Resilience Toolkit at https://crt-climate-explorer.nemac.org/.

[24] For more information see https://www.ucsusa.org/sites/default/files/attach/2018/08/extreme-heat-impacts-fact-sheet.pdf

[25] Coffel, Horton, and de Sherbinin 2017

[26] Daniel et al. 2014; Rowan et al. 2013

[27] Holsinger 2017; NBC 2017

[28] Rowan et al. 2013

go away or lessen its impacts. Solutions to the issue of climate change must focus on both adaptation to cope with the changes that lie ahead and mitigation to reduce future carbon emissions, which will limit the magnitude of future warming. Adaptation can have limits—for example port facilities need to remain on the water to serve their function and is not feasible or advisable to protect every mile of shoreline with a seawall. Because many of the adaptation-oriented solutions will require years of planning and an even longer implementation period, it is imperative that we begin planning now.

Adaptation

Policymakers must ensure that federal investments in the transportation sector strengthen the resilience of transit systems to climate change impacts while also ensuring an acceleration towards low-carbon transit systems. These efforts must also address long-standing inequities that have left many communities disproportionately exposed to climate risks.

New long-lived transportation infrastructure must be designed to withstand the future impacts of climate change. For example, to account for rising sea levels and intensifying rainstorms, infrastructure should be built at least two feet above the 100-year flood level (three feet for critical infrastructure)—a design standard that would have a high return on investment[29] and would serve as a benchmark for other public and private investments. Similar protective standards should be implemented nationwide to safeguard federally funded transportation projects from other climate impacts such as wildfires and extreme heat. The Federal Highway Administration has developed a vulnerability assessment framework that can be used to help agencies integrate climate adaptation measures into their transportation planning decisions[30].

Congress should set up a diverse and inclusive expert advisory body to provide guidance on transportation systems that not only accounts for climate change but historic injustices as well, by targeting investments in underserved and marginalized communities[31].

Congress also must invest in data and tools that can help address climate risks to the transportation sector. This means ensuring that states develop risk-based management plans and provide alternatives for transit infrastructure that is chronically in need of repairs.

Mitigation

The US transportation sector, which includes cars, trucks, planes, trains, ships, and freight, produces nearly thirty percent of all US global warming emissions[32]. This is more than any other sector. Over 90 percent of the fuel used for transportation is petroleum-based, with gasoline and diesel being the primary fuels. Given its contributions to global warming emissions, the transportation sector is in the position of being both a major contributor to global warming and highly vulnerable because of that warming. Because of this, the transportation sector would benefit greatly from global emissions

[29] See NIBS 2018. The return on investment is as much as 11:1 for roads and railroads. https://cdn.ymaws.com/www.nibs.org/resource/resmgr/docs/NHMS-UtilitiesFactSheet.pdf

[30] https://www.fhwa.dot.gov/environment/sustainability/resilience/adaptation_framework/climate_adaptation.pdf

[31] https://www.ucsusa.org/sites/default/files/attach/2017/11/gw-whitepaper-smart-infrastructure.pdf

[32] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

reductions; and the world would benefit greatly from emissions reductions from the transportation sector. There are many policies that could result in transportation emissions reductions while also reducing human exposure to harmful pollution, the burden of which falls disproportionately on traditionally underserved communities[33]. Such policies include, but are not limited to[34]:

- Increasing fuel economy and greenhouse gas emissions standards for vehicles[35]
- Increased investment in low-carbon public transportation systems, such as rail systems
- Replacing gas-powered public bus fleets with electric bus fleets[36]
- Incentivizing deployment of more electric vehicles, including through investment in charging infrastructure
- Research on highly efficient conventional vehicle technologies, batteries for electric vehicles, cleaner fuels, and emerging new technologies
- Implementing a market-based cap and invest program for the transportation sector, such as the proposed Transportation and Climate Initiative[37].

Action is needed

Long-term underinvestment in our nation's transportation infrastructure has resulted in a system that is already strained today. Recent climate events have exposed just how vulnerable our transportation networks are to climate-related events; future population growth and increasingly frequent extreme climate events will exacerbate the transportation sector's existing challenges.

Our transportation infrastructure needs to be built to last so that it is safe and reliable in the face of a changing climate. As we look to the future, we can make our transportation systems more resilient and adaptable by incorporating climate-safe design standards into the planning process. At the same time, rapidly transitioning to low-carbon transportation systems could significantly reduce emissions from the transportation sector and thus help to limit the scale of future warming and its impacts.

[33] Reichmuth, D. 2019. Inequitable exposure to air pollution from vehicles in California. Union of Concerned Scientists, Oakland, CA. https://www.ucsusa.org/sites/default/files/attach/2019/02/cv-air-pollution-CA-web.pdf
[34] For more information see https://www.ucsusa.org/clean-vehicles/fuel-efficiency/clean-car-standards.html
[35] https://www.ucsusa.org/clean-vehicles/fuel-efficiency/clean-car-standards.html
[36] https://ww2.arb.ca.gov/news/california-transitioning-all-electric-public-bus-fleet-2040
[37] https://www.transportationandclimate.org/content/about-us
https://www.ucsusa.org/sites/default/files/attach/vehicles-ne-transportation-factsheet.pdf