Climate & Community Institute

Technical Paper | The Sprawling Costs and Missed Opportunities of Highway Expansions

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To read the full report, see Letting People Move

Highways are massively expensive in direct, financial terms: the US Interstate Highway System is one of the most enormous public works projects in world history. In 2024, each additional lane-mile of highway costs between $2.5 million at a minimum and up to $50 million.[1] But the full, economic cost—which includes negative externalities and opportunity costs[2]—is much larger.

This project is one in a growing body of scholarship showing how new highway expansions entail massive costs and missed opportunities, tending to fail cost-benefit analyses—often spectacularly.

Conversely, reducing car dependency by investing in transit and walkable streets connects people to destinations while avoiding many of the direct and indirect costs of highway expansions—improving quality of life and social

[1] Nall, Clayton. 2018. The Road to Inequality: How the Federal Highway Program Polarized America and Undermined Cities. Cambridge, United Kingdom ; New York, NY: Cambridge University Press.; U.S. Department of Transportation, Federal Highway Administration and Federal Transit Administration. 2024. "Status of the Nation's Highways, Bridges, and Transit: Conditions & Performance Report to Congress, 25th Edition". https://www.fhwa.dot.gov/policy/25cpr/pdf/CP25_Full_Report.pdf.

[2] Negative externalities are undesired social consequences that impact people not directly participating in a decision or activity (in this case, driving, building highways). Opportunity costs are what could be done instead, as contrasted with the financial cost, or direct cost in dollars. In this case, . In this case, the opportunity cost is building transit instead of highways.

connectedness,[3] reducing reliance on oil and energy transition minerals,[4] and helping mitigate climate change.[5]

Our transportation system is a massive intervention on the built environment with far-reaching consequences. The model we introduce here compares investments in highway expansions against an opportunity cost of investing in public transit. The impacts included in our model are extensive but not exhaustive. Investments in public transit and supportive policies tend to have additional, substantive impacts – on social trust, life satisfaction, commute times, and economic productivity – but these are left outside of our modeling here.[6]

Impacts of shifting dollars from highways to transit

Our original modeling sheds light on many of the direct costs and opportunity costs of building or widening highways. **Every billion dollars spent on building or widening highways instead of transit, on average:**

- **Induces 1.8 billion additional vehicle miles traveled (VMT) on the highway system every year.** Traffic expands as the space given to it increases. This tendency is referred to as "induced travel" or the "fundamental law of highway congestion." Shifting transportation dollars to transit has the reverse effect. This estimate of VMT reductions is extremely conservative, because it only includes VMT reductions on highways and not local roads.
- **Costs over $1.7 billion in annual, dollarized social costs**. These are from car crashes, deaths, greenhouse gas emissions and other forms of air pollution, averted traffic congestion from improved transit, and maintenance costs on the new road areas. This estimate of dollarized savings is very conservative because VMT on local roads are omitted

[3] Talmage, Craig A., and Chad Frederick. 2019. "Quality of Life, Multimodality, and the Demise of the Autocentric Metropolis: A Multivariate Analysis of 148 Mid-Size U.S. Cities." Social Indicators Research 141, no. 1: 365–90. https://doi.org/10.1007/s11205-017-1829-4.; Liu, Jiakun, Dick Ettema, and Marco Helbich. 2022 "Systematic Review of the Association between Commuting, Subjective Wellbeing and Mental Health." Travel Behaviour and Society 28: 59–74. https://doi.org/10.1016/j.tbs.2022.02.006.

[4] Riofrancos, Thea, et al. 2023. "Achieving Zero Emissions with More Mobility and Less Mining." http://www.climateandcommunity.org/more-mobility-less-mining.

[5] Milovanoff, Alexandre, et al. 2020. "Electrification of Light-Duty Vehicle Fleet Alone Will Not Meet Mitigation Targets." Nature Climate Change 10, no. 12: 1102–7. https://doi.org/10.1038/s41558-020-00921-7.; McDonald, Kira. 2023. "Transportation: A Blindspot in US Climate Policy." Climate and Community Institute (blog). https://climateandcommunity.org/research/blog-transportation-blindspot/.

[6] Some of these other impacts are discussed briefly in the literature review section of the appendix.

and not all social costs are dollarized.[7] This aggregated economic estimate attempts to put a dollar value to a range of actual outcomes: car crashes and traffic deaths; lives shortened by air pollution exposure and climate change; time wasted sitting in traffic; and road maintenance costs down the line.

- o **Less abstractly, that translates to an averted 1,400 injuries and 24 deaths from car crashes, 600 thousand metric tons fewer CO^2 emissions, $200 million of savings from reduced car traffic, and 150 tons of air pollutants of various types not emitted in population centers.** This avoided localized air pollution would include volatile organic compounds (VOCs), nitrogen oxides (NOx), and tiny particulate matter (PM2.5), often composed of microplastics or other petrochemical debris, which contribute enormously to a variety of serious health harms.[8]

- **Induces nearly eight-thousand additional acres of urban sprawl.**[9] New highway capacity induces VMT in the short-term by providing more space for cars and in the long-term by facilitating highway-oriented developments in the future. Residents of new developments along expanded highways will be more car-dependent and have longer commutes to reach existing developed areas. Alternatively, more spatially-efficient development patterns, facilitated by public transportation, can help shorten trips and create open space for recreation and to protect biodiversity and the climate.

- **Forfeits nearly $600 million in lost land value**. This is primarily from the spatial opportunity cost of land that could otherwise be used for other purposes, but it also includes the net negative impacts of highways on land values at the metro level. This estimate does not capture the human cost of homes, businesses, or public services that may be demolished or displaced by highway construction.

[7] VOCs and induced sprawl are two modeled outcomes that are not given a dollarized social cost.

[8] Wallace-Wells, David. “Ten Million a Year: Dying to Breathe.” London Review of Books, December 2021. https://www.lrb.co.uk/the-paper/v43/n23/david-wallace-wells/ten-million-a-year.

[9] Urban sprawl can be characterized as less connected and lower-density development, likely with population densities below 10 persons per acre, more cul-de-sacs or a less connected street network, more curving roads, and more space between developed areas.

Annual benefits of shifting $1 billion from highway expansion to transit:

1,808,500,000	Reduced vehicle miles traveled
24	Lives saved
1,400	Injuries avoided
622,000	Tons of CO2 equivalent emissions eliminated
170	Tons of air pollutants (NOx, PM2.5, VOC) eliminated
$188,150,000	Savings in reduced traffic delays
$26,101,000	Reduced road maintenance costs

Shifting highway funds to transit provides scalable social, economic, and environmental opportunities.

There are many ways to shift funds away from highways and towards transit. For example, shifting $74 billion—just half of the budget that the Infrastructure Investment and Jobs Act (IIJA) allocates to the National Highway Performance Program (NHPP)—would result in:


134 billion fewer vehicle miles traveled


1,800 lives saved and 104,000 injuries prevented


46 million tons of CO2 and 12,300 tons of air pollutants prevented


$14 billion in savings from fewer traffic delays


$2 billion in road maintenance costs saved

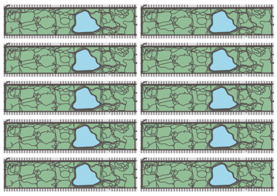
These outcomes occur every year, compounding the benefits of shifting funds over time.

Investing in transit instead of highways saves land.

Every $1 billion spent on building or widening highways turns nearly 8,000 acres into suburban sprawl and forfeits $580 million in land value.

By investing $1 billion in transit instead, 8,000 acres could either:

Provide up to 250,000 homes
(versus as few as 32,000 if highways are funded instead)[10]



Create open space equivalent to 10 Manhattan Central Parks[11]

Avoid emissions of 1.3 million tons of CO2 from degradation of natural land[12]

Or grow enough wheat to bake 23 million loaves of bread each year[13]

Mechanisms that allow states to transfer money from highways to transit are already in place, and it is possible to begin making these shifts in the short term. A very large share of federal highway aid dollars can be shifted between transportation programs, but most states are not currently taking full advantage of this possibility, as we have shown in our companion tool, How Are

[10] CCI original analysis using the JHP Architecture / Urban Design Calculator Density Guide (https://jhparch.com/density) and 2023 American Community Survey 5-year estimates of population density in medium-density neighborhoods versus suburbs.

[11] "Park History," Central Park Conservancy, https://www.centralparknyc.org/park-history.

[12] CCI original analysis using the United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator - Calculations and References (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator-calculations-and-references) for "Acres of U.S. forest preserved from conversion to development."

[13] CCI original analysis using United States Department of Agriculture National Agricultural Statistics Service data (All Wheat Area Planted and Harvested, Yield, and Production – States and United States: 2021-2023), available at https://downloads.usda.library.cornell.edu/usda-esmis/files/k3569432s/ns065v292/8910md644/cropan24.pdf. Calculation was made using the 2023 yield of 48.6 bushels per acre, or 2,916 pounds per acre. 8,000 acres would produce 23 million pounds of whole wheat flour. A typical load of bread uses about one pound of flour.

Transportation Dollars Flowing in Your State?.[14] We also outline policy solutions to more fundamentally change transportation funding and project selection at every level of government in our companion report Letting People Move: A transportation and policy agenda to address the cost of living and climate crises.

Technical Appendix

Existing research that informed our modeling

A growing body of scholarship explains how new highway expansions entail massive costs and missed opportunities, tending to fail cost-benefit analyses. Findings from this literature were used to build the described model here, providing estimates of land values, and relationships between highway and transit expansions and changes in VMT.

Guerra et al 2024 examines the opportunity cost of land value used for highways, which highlighted this additional dimension of highway costs. The authors of that paper conducted a cost-benefit analysis for new highway capacity and found the expansion failed the cost-benefit analysis when only direct financial costs were included; when externalities from induced driving and the opportunity cost of land were added in, with costs became over four times greater than benefits, even with conservative assumptions. Ray et al. 2024 conducts a case study of a similar phenomenon in Bridgeport, CT and finds that the massive spatial footprint of downtown interstates and surface parking lots each cut millions of square feet from the city's taxable land area. Garcia-López 2019 provides estimates of the rate at which highway expansions cause sprawl and suburbanization, building on a substantial body of prior work, notably Baum-Snow 2007, that establishes causal links between highway construction and sprawl or suburbanization.

A similarly established body of work has also consistently found that highway construction induces additional driving – so much so that this law of "induced demand" is also known as the "fundamental law of highway congestion."[15] Garcia-López 2022 builds on this literature by estimating the impact that public transit, particularly subways and rail, can have in reducing driving. While new

[14] McDonald, Kira, Emmett Hopkins, and Narayan Gopinathan. 2024. "How Are Transportation Dollars Flowing in Your State?" Climate and Community Institute. https://climateandcommunity.org/research/how-are-transportation-dollars-flowing-in-your-state/.

[15] Volker 2023; Duranton 2011.

highways cause more VMT, new transit, particularly rail and subway transit, can reduce it.

The modeling conducted for this project draws heavily on this prior work, using elasticities and other relationships uncovered in this literature to estimate the impacts of shifting funding between highways and transit.

As noted, our modeled impacts are extensive but not exhaustive, with substantial additional impacts strongly suggested by the literature. Building in ways that allow freedom of movement outside a car also impacts human health, happiness, and sense of community. Carson et al 2023 and Leyden 2003 found that people in more walkable neighborhoods are more likely to know their neighbors and are more trusting and socially engaged. Han et al 2022 find that public transit, especially subways, can reduce commuting time, which increases life satisfaction. Anderson 2013 shows that public transit substantially reduces commuting time even in predominantly car-dependent regions. Reducing reliance on driving, and especially facilitating trips by walking or bicycling, is shown to directly improve people's life satisfaction.[16] Finally, research in urban economics details economic benefits that accrue to density: higher wages, higher productivity in many sectors, and a smaller gap between wages and productivity – which means higher earnings and less inequality.[17] These important outcomes are not included in our model, but this literature indicates that shifting transportation investments and associated development patterns would realize benefits in these dimensions as well.

Methodology

We created a simulation model to estimate impacts of new lane-miles of highway, new route-miles of transit, and the impact of shifting funding from one to the other. This model builds on others that estimate impacts of highway widenings, such as the UC Davis Induced Demand Travel Calculator[18] or the Rocky Mountain Institute SHIFT Calculator.[19] Like those tools, this model estimates the additional VMT driving from new highway expansions. However, our tool incorporates additional relationships, informed by recent new research, to estimate impacts of building transit instead of highways and estimate additional indirect impacts of the highway from such a shift.

The flow of our model is diagrammed in Figure 1. We merged data from the Federal Highway Administration (FHWA) with VMT and highway lane-miles at

[16] Saadaoui 2025; Chatterjee 2019; Zhu 2018.

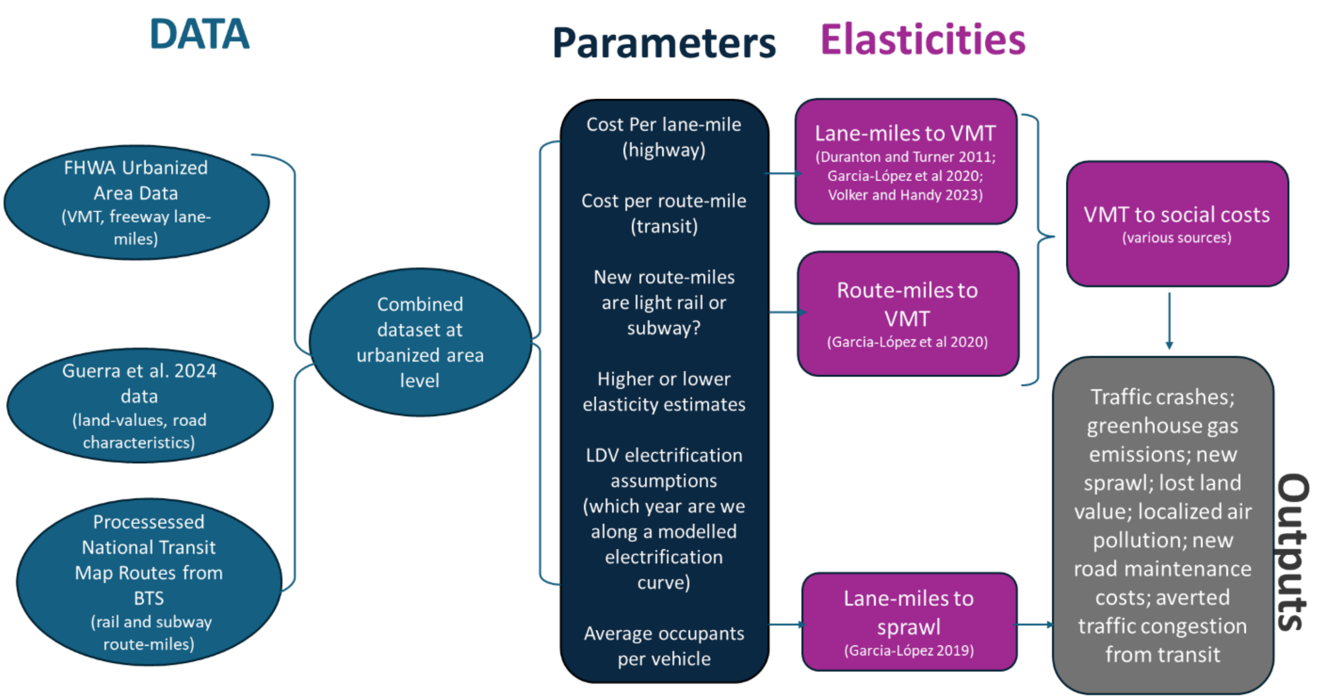
[17] Glaeser 2009; Hirsch 2022; Bartoloni 2023.

[18] https://travelcalculator.ncst.ucdavis.edu/

[19] https://shift.rmi.org/

the urbanized area level with census-tract level data from Guerra et al. 2024, which include land values and additional road characteristics. Finally, we processed the National Transit Map (NTM) from the Bureau of Transportation Statistics (BTS), which provides national coverage of transit routes by type. This data allowed us to link light-rail and subway route-miles to urbanized areas.

Figure 1: Simulation model flow



Parameterization

Efforts to estimate impacts from interventions in any complex system are by necessity subject to countless large and small decisions that can impact results. In the modelling here, assumptions about the relative costs of highway and transit expansions or the rate at which highway expansions induce traffic are examples of such decisions. To manage this, we ran the model one thousand times with parameters randomized over reasonable ranges.[20]

By comparing results across simulation runs, we can see the robustness of our results to these decisions. We handled the following parameters this way:

[20] This approach could be described as a Monte Carlo Simulation.

- Cost per lane-mile highway: Costs taken from a truncated normal distribution with a mean of $5.5 million per lane-mile, based on reported "typical costs of widening, per urban lane mile" from FHWA.[21]

- Cost per route-mile transit: Costs taken from a truncated normal distribution with an average of $450 million per route-mile and a standard deviation of $150 million, based on data from the Transit Project.[22] The US currently sees transit construction costs two or three times higher than in peer counties: over twice as much as Canada or Mexico in PPP-adjusted real dollars and over three times as much as Spain, Switzerland, China, or numerous other countries. The average parameter here reflects US costs declining to about the level of Canada or Mexico, reflecting the expectation that costs of transit construction can be brought down with practice, while the higher end of simulated costs will be closer to current averages in the US.

- Whether the new rail is subway: Subway tends to cost more than light rail, but based on available estimated elasticities, it also averts more VMT per route-mile. When the randomized costs were greater than $500 million/route-mile, the model gives the route a 2/3rds chance of being subway. Notably, subway costs substantially less than this in many countries with lower transit capital costs than in the US.

- Higher or lower elasticity estimates: the elasticity, or relationship, between new highway lane-miles and vehicle-miles traveled (VMT) has been estimated in numerous academic papers, with long-term estimates clustered around 1—meaning a 10% increase in highway lane-miles induces a 10% increase in highway VMT. A recent paper which also controls for the negative effect of transit on VMT finds a substantially higher elasticity, at 1.4 (a 10% increase in lane-miles induces a 14% increase in highway VMT). The parameters for elasticity are drawn from a normal distribution with an average of 1.2 and a standard deviation of 0.1, so nearly all values will be between 1 and 1.4.

- Year along EV adaptation curve: Car or light-duty vehicle (LDV) VMT produce greenhouse gas and NO2 (Nitrogen Dioxide) emissions at different rates when they are or aren't electric. We assume electric vehicles are powered from a zero-emission grid and therefore don't produce GHGs. The proportion of LDVs that are electric is defined by a fleet turnover and electrification model, with the year for which annual

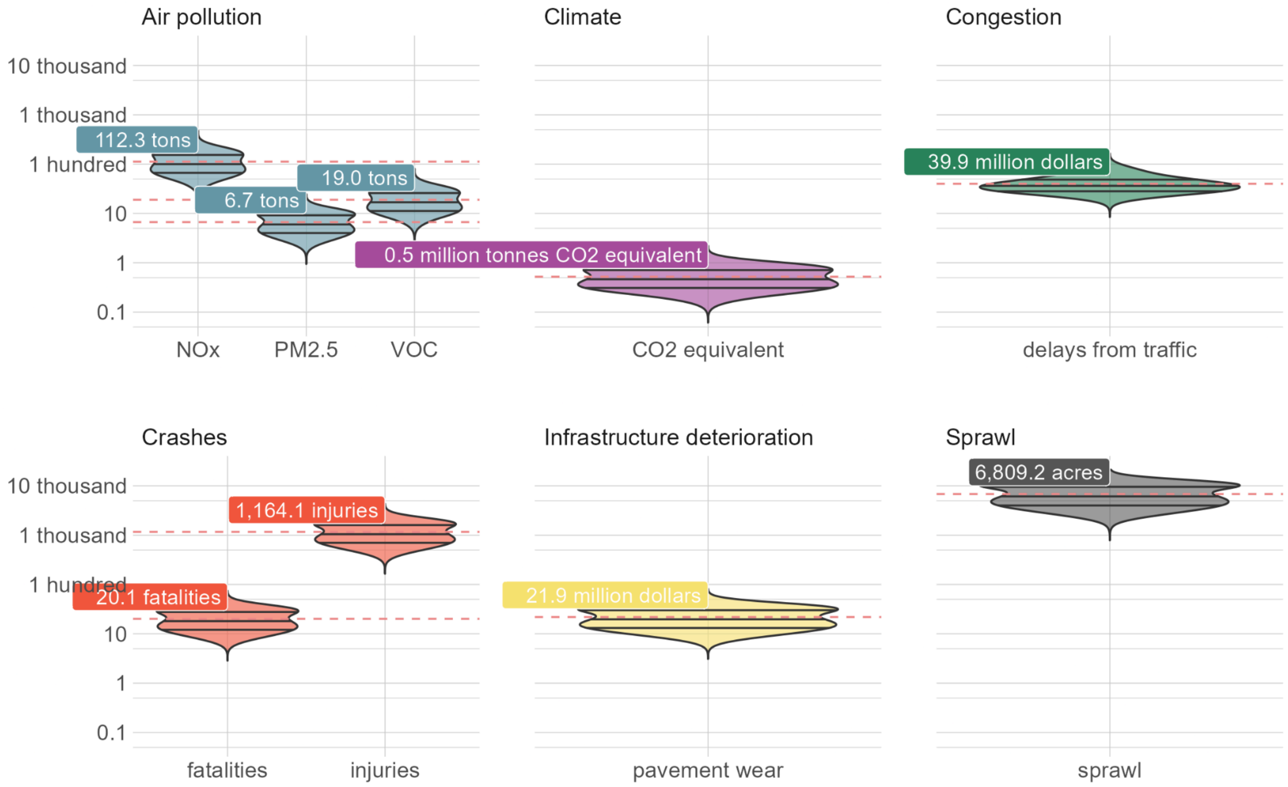
[21] https://www.fhwa.dot.gov/policy/25cpr/pdf/CP25_Full_Report.pdf

[22] Levy 2025.

GHG emissions will be calculated taken as a randomized parameter between 2027-2040.[23]

The parameters result in a wide range of outcomes that cluster within a much tighter interquartile range. Figure 2 shows how the parameters across simulations affect results in the New York-Newark urbanized area, and Table 1 shows the quartiles for each outcome. The parameters that result in the minimum benefits from shifting spending have extremely high costs for both new rail and new highway construction, with new rail light rail rather than subway despite the high costs, and a lower elasticity between lane-miles and VMT. Conversely, the high-benefit model runs have much lower costs for both infrastructures and a high estimated lane-mile/VMT elasticity; parameters for the model runs which resulted in the largest and smallest VMT shifts in the New York-Newark urbanized area are shown in Table 2.

Figure 2: Social costs across 1000 model simulations in New York – Newark Urbanized area



[23] The fleet turnover and electrification curve was developed through a prior project. https://climateandcommunity.org/research/more-mobility-less-mining.

Table 1: Externalities by quartile for New York-Newark urbanized area, across model simulations

	0%	25%	50%	75%	100%
CO2 equivalent (million metric tons)	0.12	0.31	0.45	0.73	1.15
Delays from traffic (dollarized value, millions)	16.31	29.15	35.77	45.69	85.72
Fatalities	5.49	12.34	17.50	29.29	38.78
Injuries	317.61	714.30	1013.24	1695.50	2245.02
NOx (tons)	25.40	67.53	97.80	156.47	248.96
pavement wear (dollarized value, millions)	5.96	13.41	19.03	31.84	42.16
PM2.5 (tons)	1.82	4.09	5.80	9.71	12.86
VOC (tons)	4.28	11.39	16.50	26.39	41.99
Induced sprawl (acres)	1514	4085	6004	11020	11020

Table 2: Parameters that generated highest and lowest shifts, of 1,000 simulations, for New York-Newark urbanized area

Amount shifted ($)	cost per lanemile (million $)	cost per rail route-mile (million $)	Whether the rail is subway	Average passengers per car	Elasticity between highway lane-miles and VMT	Year along modeled EV adaptation curve
1 billion	21.8	555	Yes	1.67	1.2	2039
1 billion	3.0	248	No	1.47	1.4	2038

The variation in outcomes achieved through this simulation process demonstrates both the bounded uncertainty of possible outcomes, and the bundling of outcomes around likely averages. However, **this distribution is also policy relevant because it shows the impacts of other factors beyond shifting spending alone.** Reducing the construction costs of rail, and aiming to maximize the shifts to lane-miles by using supplementary policies to encourage mode shift (such as land use, zoning, and building code reforms or congestion pricing schemes) will help increase benefits further, beyond the averages reported above.

Reporting results

Even more significant in this instance is how results are reported or summarized. Many of the relationships that underlie the model are non-linear: new highway or transit construction induces or averts VMT based on the extent of existing infrastructure and existing volume of VMT in a particular metro area; the opportunity cost of land-values will depend on where the highway is built or expanded. Our summary of results uses population-weighted averages across metro areas and model simulations. Figure 3 shows the distribution of outcomes as well as the reported weighted averages and Figure 4 shows the averted social costs across all metros and all model simulations.

Figure 3: Distribution of outcomes across simulations and urban areas

Our simulation model was run 1,000 times with randomly generated parameters, but results tend to vary more across urbanized area than across simulation runs. This figure shows the distribution of results across all model runs and all urbanized areas. Notably, some outputs, such as impacts on land values and averted VMT from transit expansions are far more variable than others, such as induced sprawl or averted VMT from not expanding a highway. '

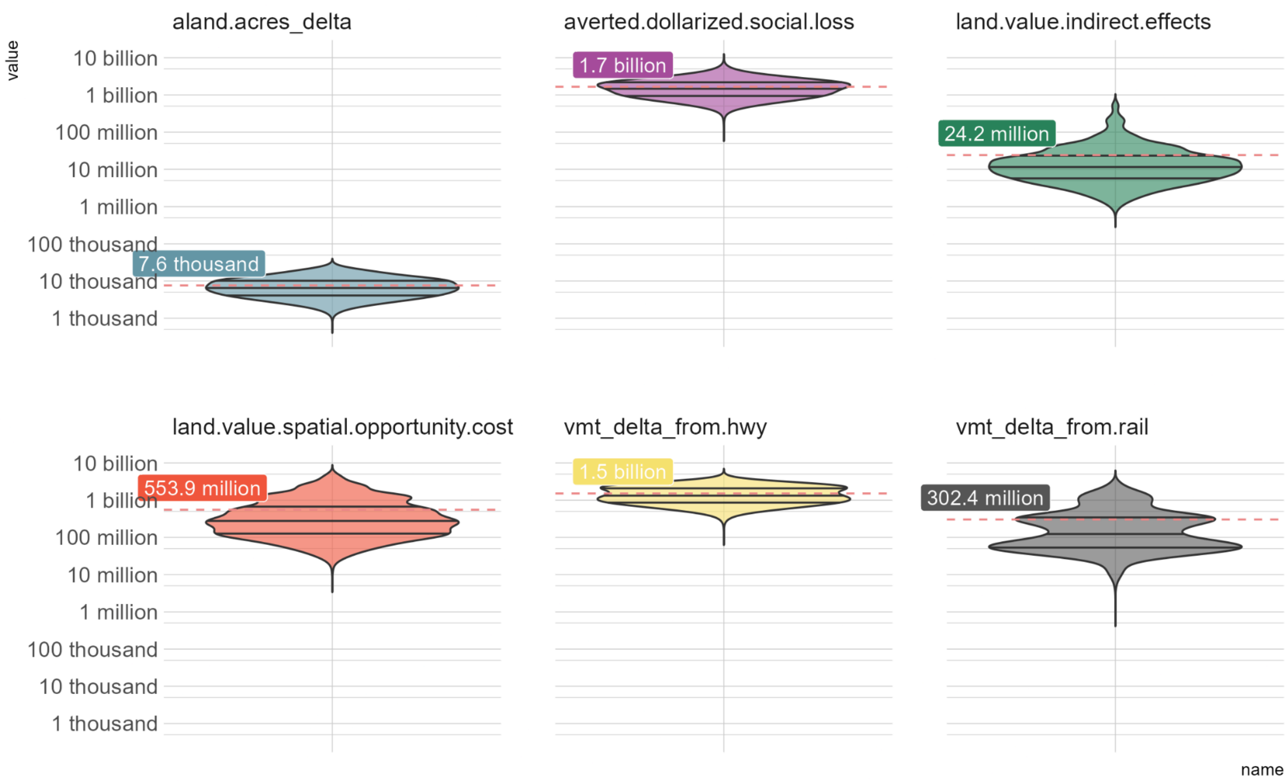
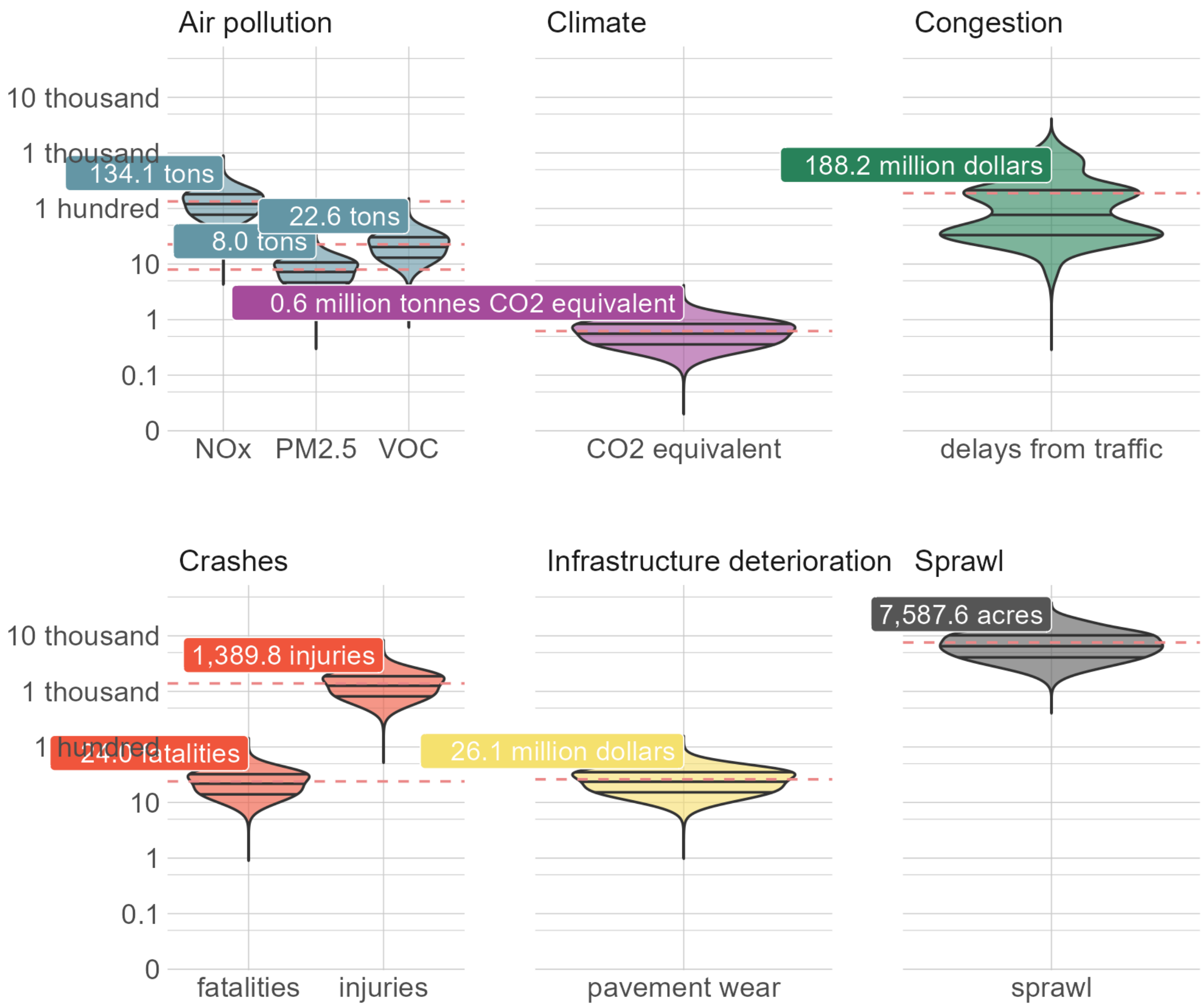
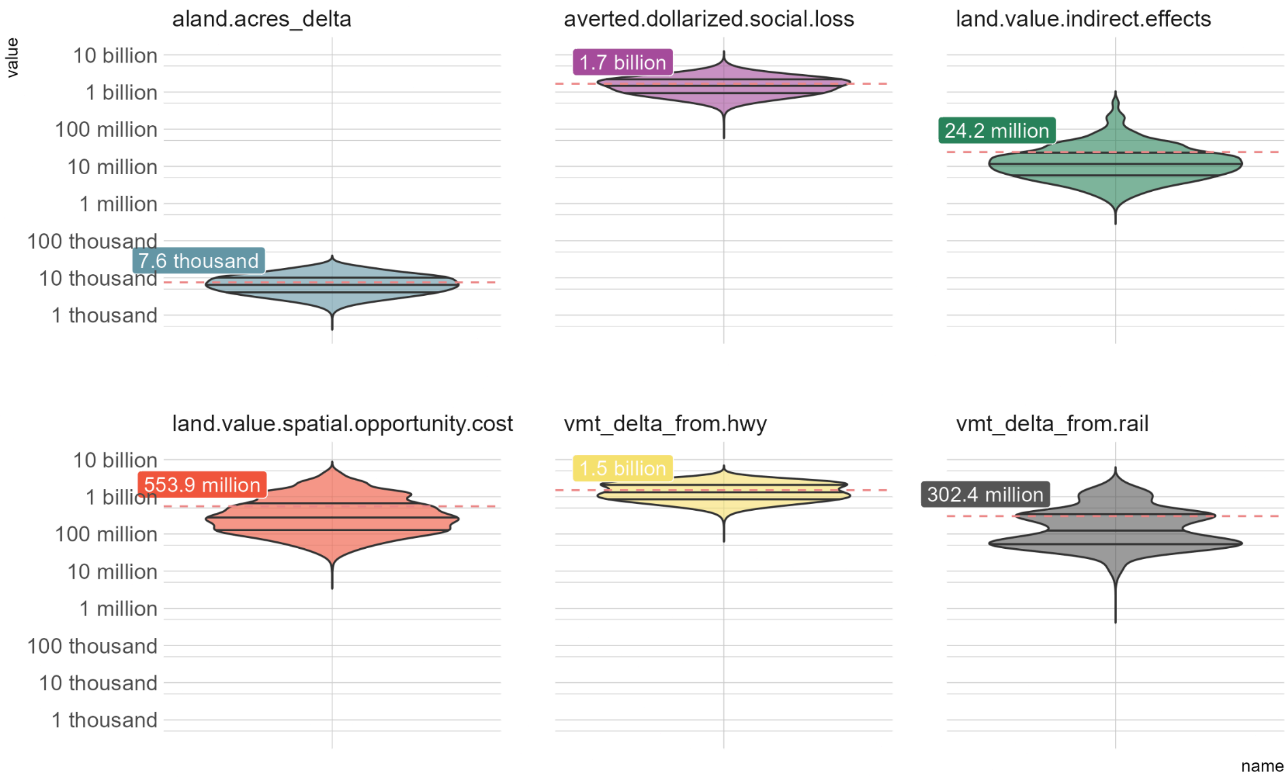


Figure 4: Averted social costs, all metros and all model simulations





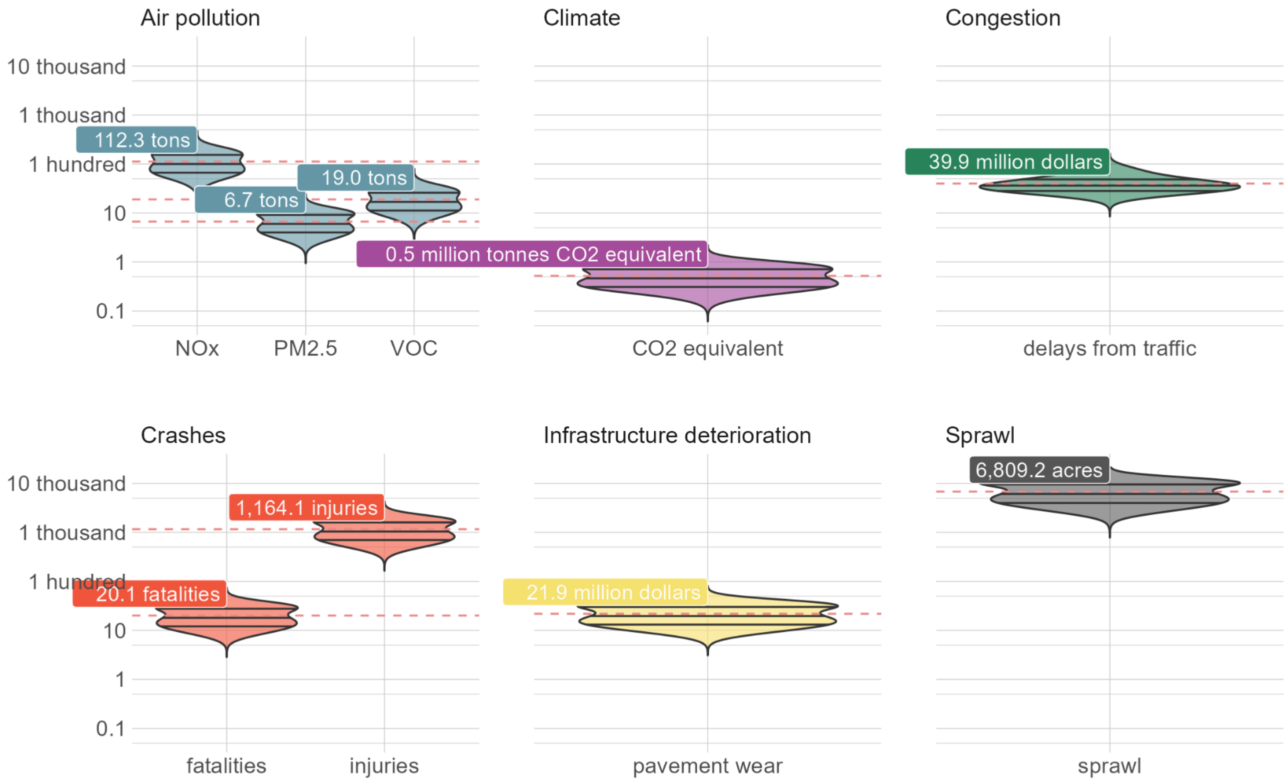
National and metro-level results

Many of the relationships that underlie the model are geographically specific: New highway or transit construction induces or averts VMT based on the extent of existing infrastructure and existing volume of VMT in a particular metro area; the opportunity cost of land-values will depend on where the highway is built or expanded. For example, the median forfeited land value from spending $1 billion on highways, across model simulations, is much higher in the New York-Newark urbanized area, where it is around $720 million, relative to Phoenix-Mesa, where it is $180 million.

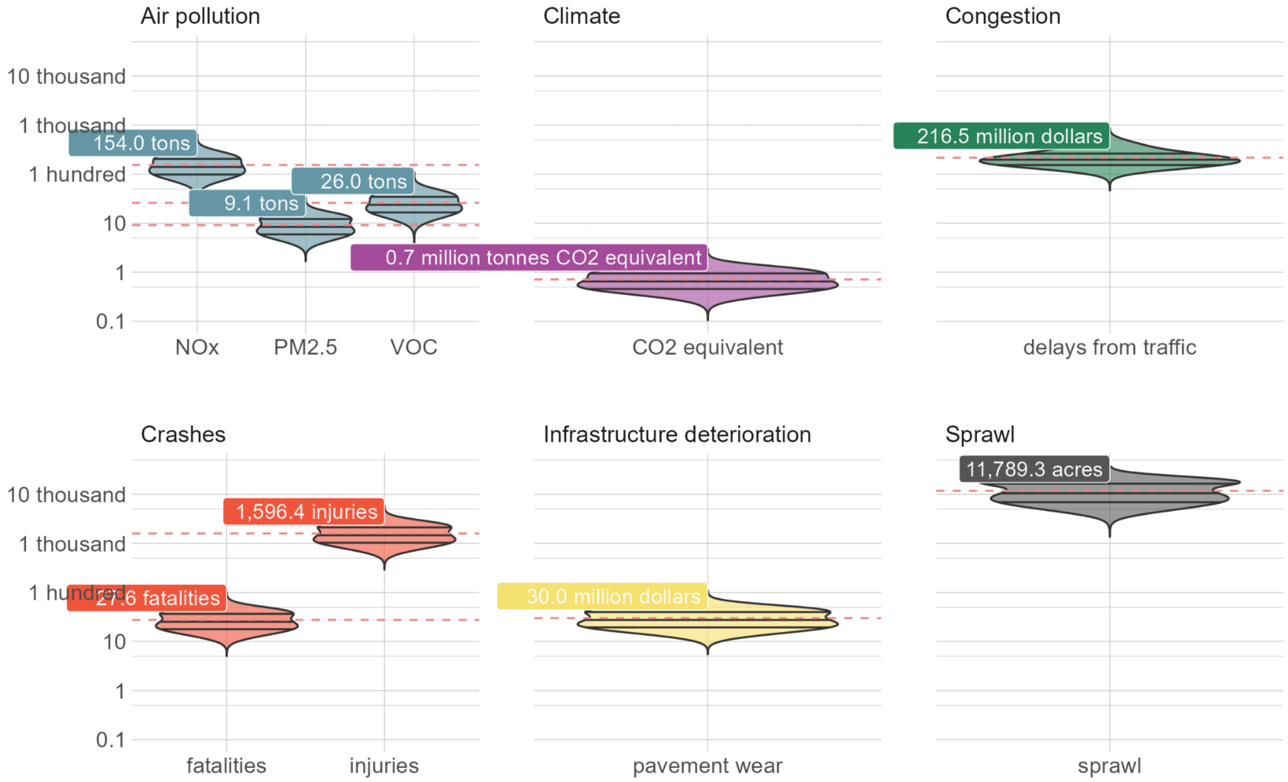
As noted, our summary of results uses population-weighted averages across metro areas and model simulations. This could be interpreted as the impacts of spending shifts in a hypothetical "average metro." However, results can also be reported for specific metros or sets of parameters. A series of plots below shows the distributions of impacts across model simulations for a series of selected metros. All figures will show impacts or averted costs from shifting $1 billion from highways to transit.

Distribution of averted social costs for selected metros, all model simulations

New York – Newark:

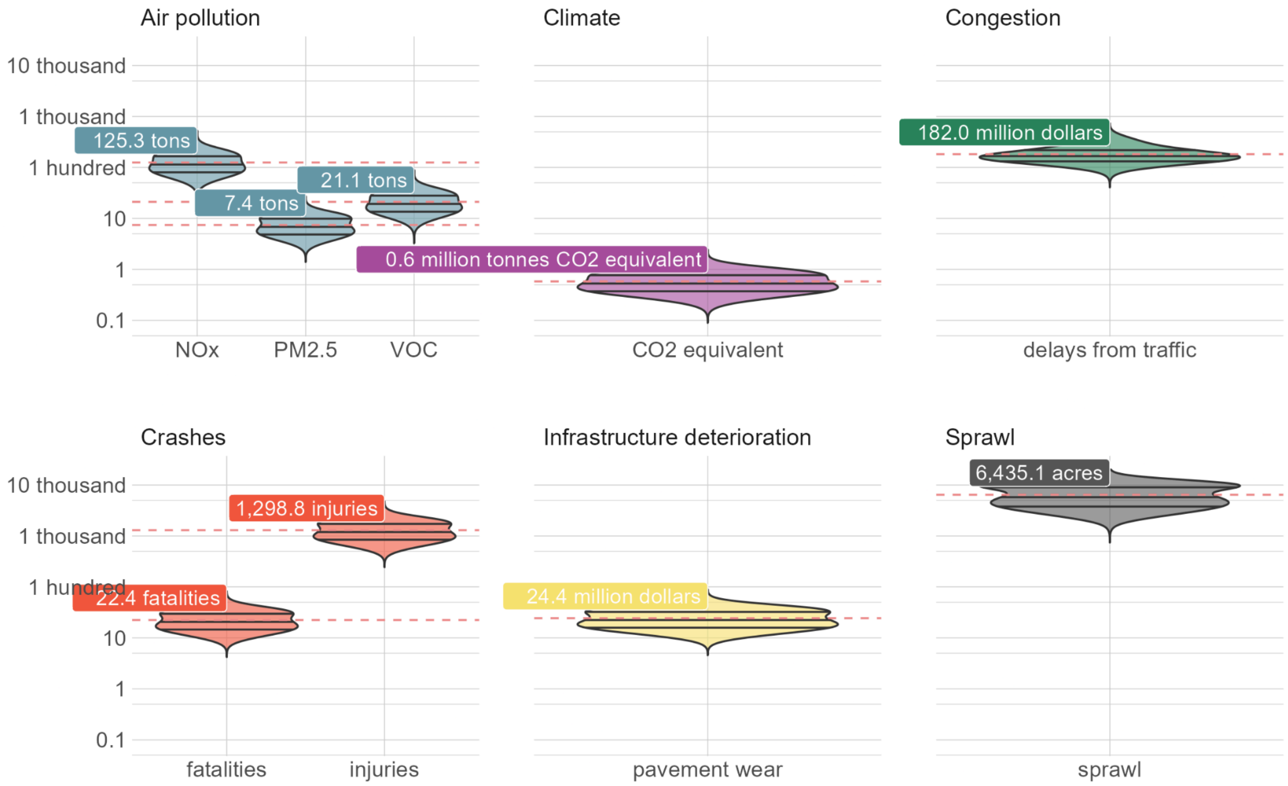


Chicago:

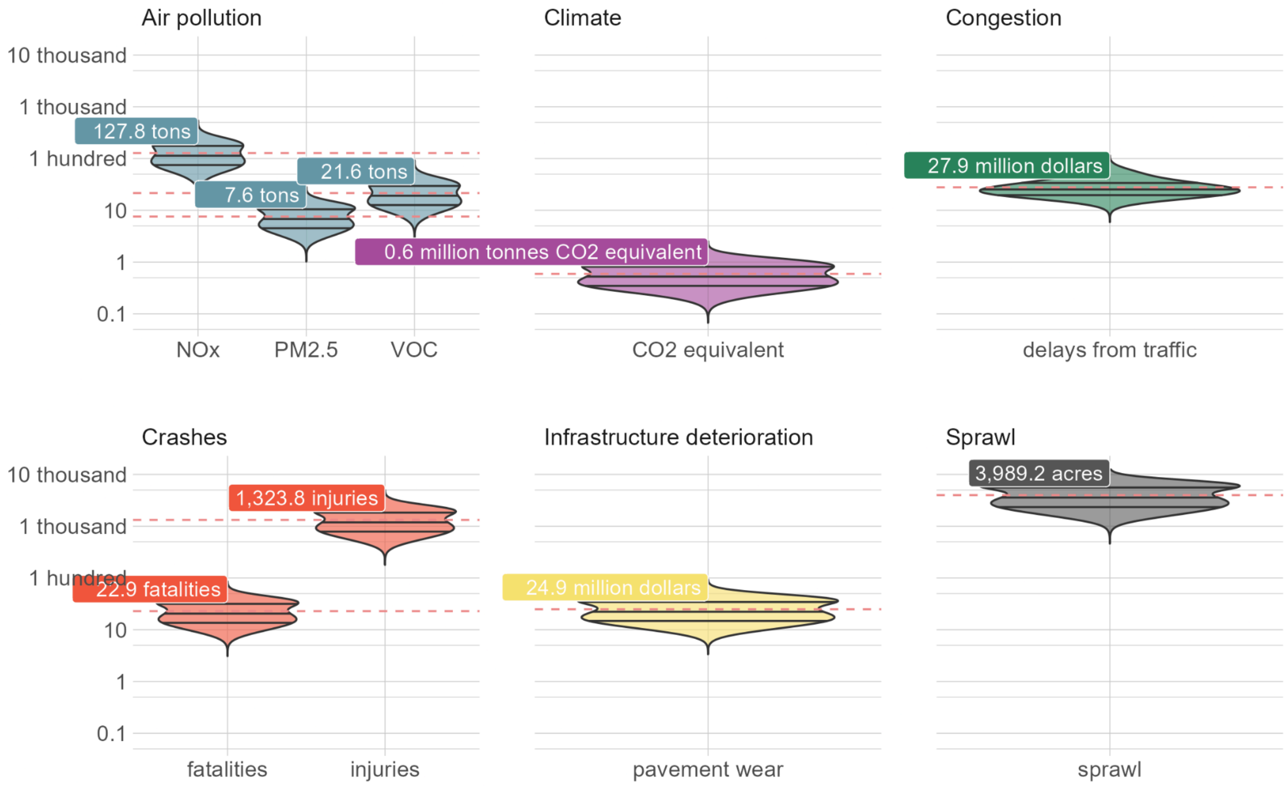


Air pollution
Climate
Congestion
10 thousand
1 thousand
1 hundred
10
1
0.1
154.0 tons
9.1 tons
26.0 tons
0.7 million tonnes CO2 equivalent
216.5 million dollars
NOx
PM2.5
VOC
CO2 equivalent
delays from traffic
Crashes
Infrastructure deterioration
Sprawl
1,596.4 injuries
27.6 fatalities
30.0 million dollars
11,789.3 acres
fatalities
injuries
pavement wear
sprawl

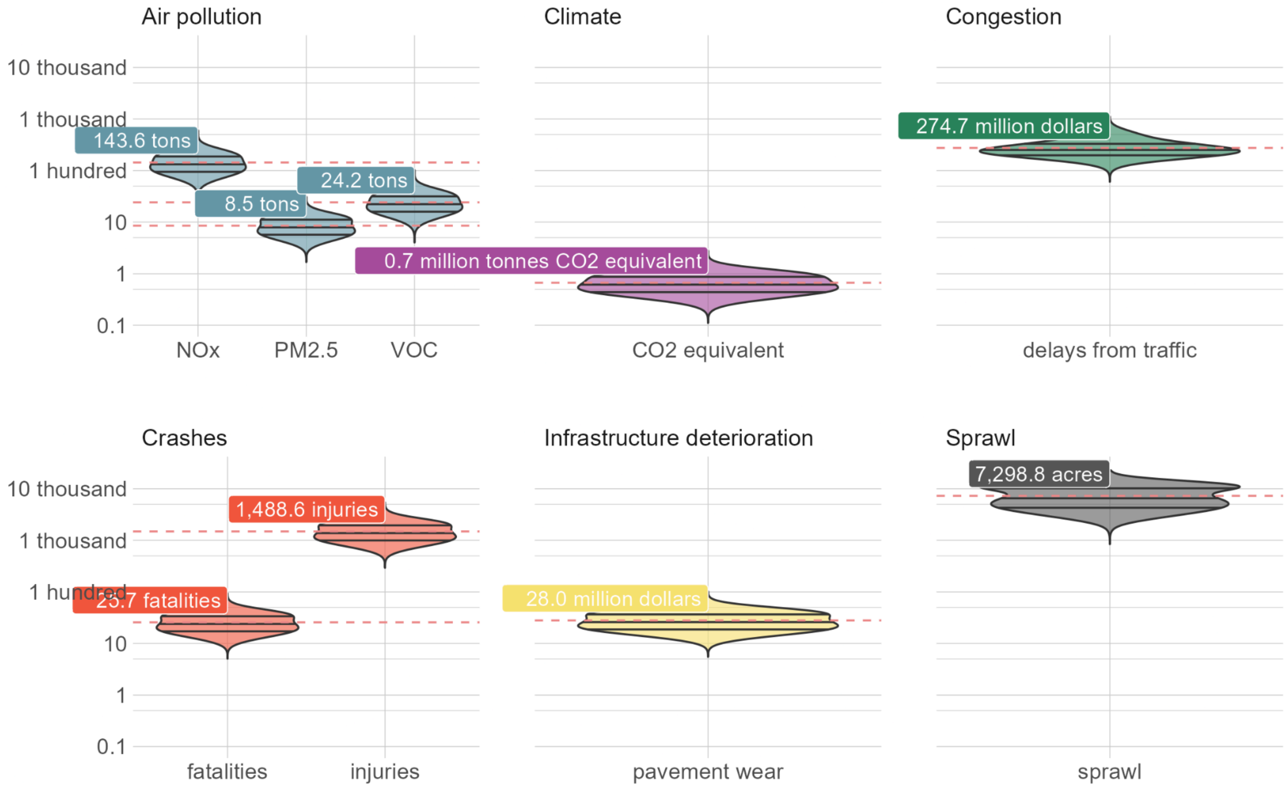
Austin:


Air pollution
Climate
Congestion
10 thousand
1 thousand
1 hundred
10
1
0.1
125.3 tons
7.4 tons
21.1 tons
0.6 million tonnes CO2 equivalent
182.0 million dollars
NOx
PM2.5
VOC
CO2 equivalent
delays from traffic
Crashes
Infrastructure deterioration
Sprawl
1,298.8 injuries
22.4 fatalities
24.4 million dollars
6,435.1 acres
fatalities
injuries
pavement wear
sprawl

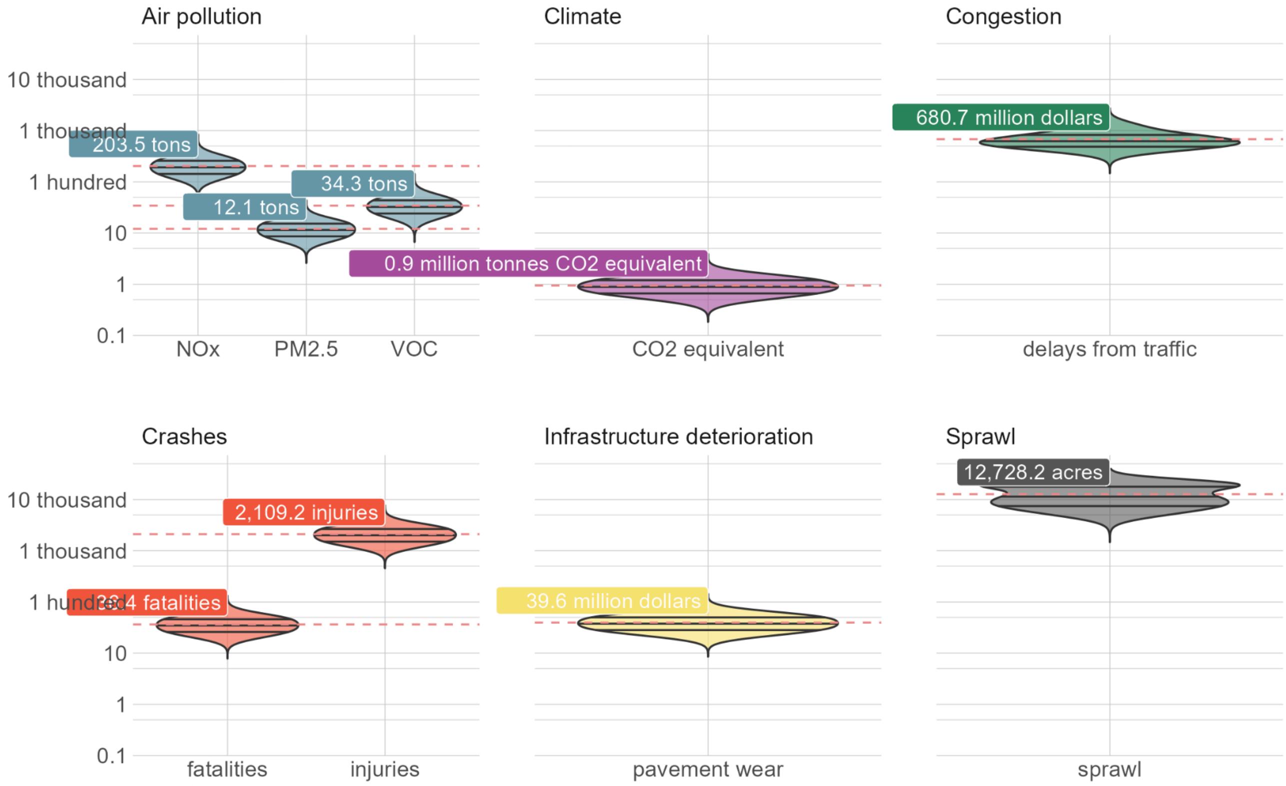
San Francisco – Oakland:



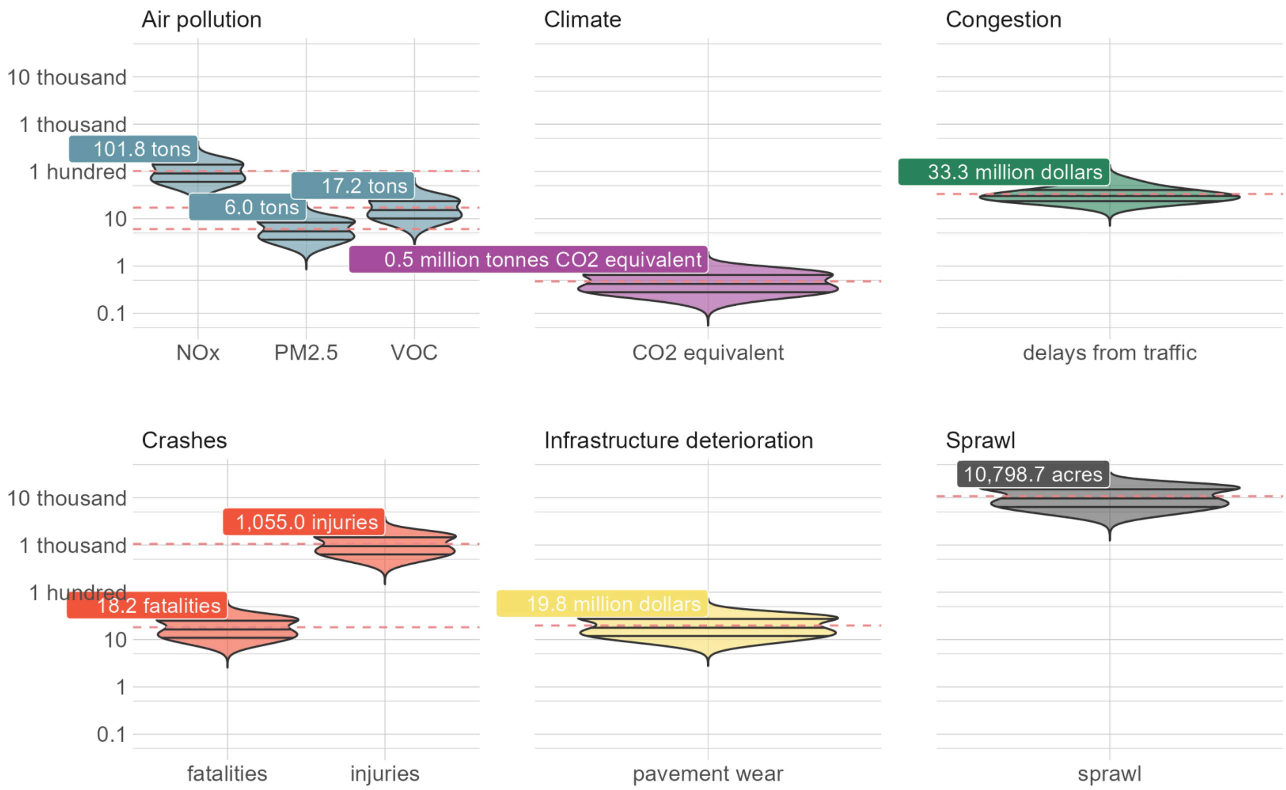
Phoenix – Mesa:



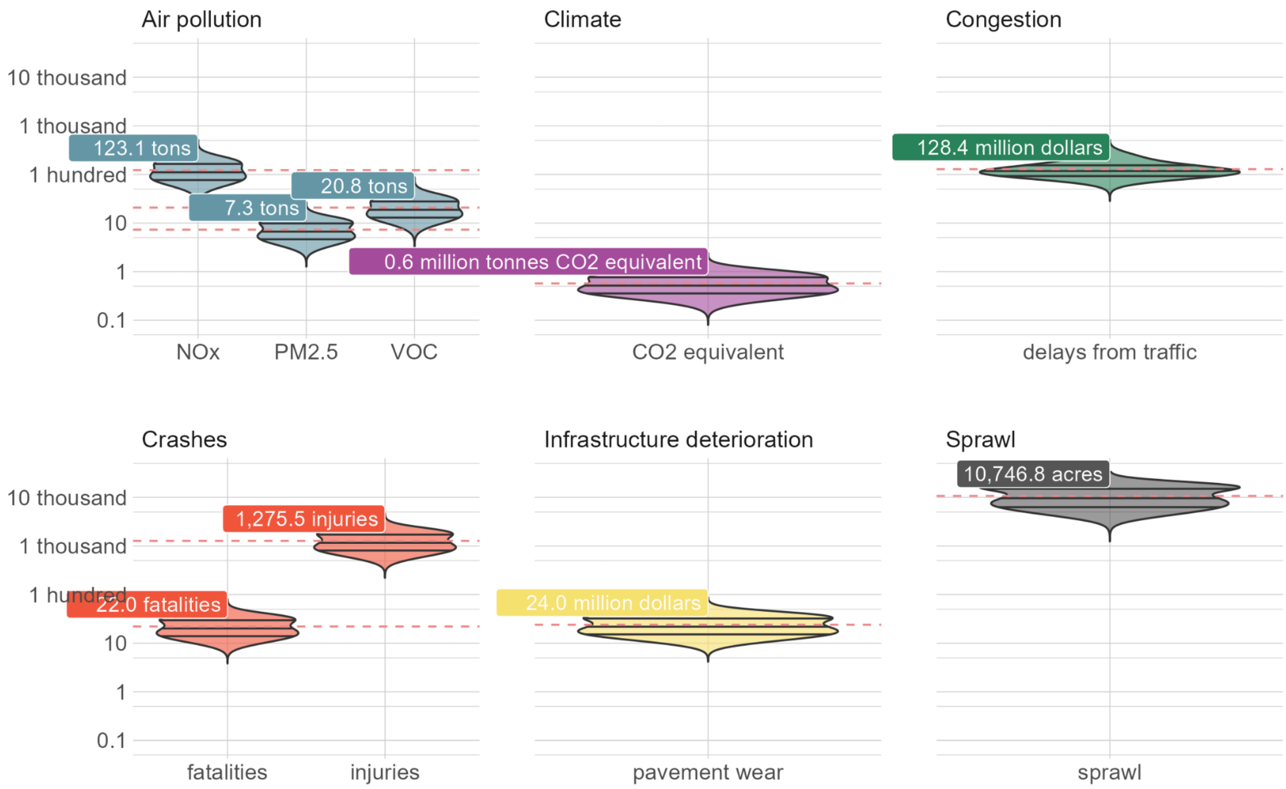
Atlanta, GA:


Air pollution
Climate
Congestion
10 thousand
1 thousand
1 hundred
10
1
0.1
203.5 tons
12.1 tons
34.3 tons
0.9 million tonnes CO2 equivalent
680.7 million dollars
NOx
PM2.5
VOC
CO2 equivalent
delays from traffic
Crashes
Infrastructure deterioration
Sprawl
2,109.2 injuries
fatalities
39.6 million dollars
12,728.2 acres
fatalities
injuries
pavement wear
sprawl

Philadelphia, PA-NJ-DE:



Charlotte, NC-SC:



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