Transportation Resilience Benefit-Cost Analysis Case Study

Transit: Bus Stop

Case Study

Overview: The National Capital Region Transportation Planning Board (TPB) has conducted five benefit-cost analysis (BCA) case studies of transportation assets within the National Capital Region to demonstrate the cost of inaction, compare low-cost and high-cost solutions, and provide support for the benefits of proactive resilience investment.

Study Site: The focus of this case study is the Army Navy Drive & South Joyce Street westbound southbound bus stop in Arlington, VA. This Metrobus and Arlington Transit bus stop serves roughly 70 riders per day and lacks existing shelter or vegetation.

Context: Studies, such as those by the Center for American Progress,[i] show that exposure to extreme heat results in increased emergency department (ED) visits and hospitalizations, and that the number of days with extreme heat is expected to increase. Research published by Arizona's Sun Tran bus service[ii] and Lanza et al. (2025)[iii] shows that shelters and surrounding vegetation can lower ambient and ground temperatures and help mitigate health impacts at bus stops. This case study examines a low-cost solution of erecting a bus shelter and a high-cost solution of supplementing the shelter with additional trees and foliage to lower temperatures around the stop. In addition, the new bus shelter would provide space for advertising, thereby producing advertising revenue.

Results: BCA results suggest that the low-cost and high-cost solutions have discounted (3.1%)[iv] benefit-cost ratios of 3.0 and 2.7, respectively. These results imply that for every $1 invested in solutions, there is a return of nearly $3 in health and advertising revenue benefits. Net benefits are estimated at around $100,000 over 20 years.

Key Takeaways

- Shelters and foliage solutions at bus stops can significantly lower ambient temperatures, resulting in decreased health costs.
- Over 20 years, no investment could result in nearly $7,000 in health impacts at a single location.
- Results suggest a 3:1 ROI for proactive investment.
- Similar action could be taken at a regional level to address health concerns in the National Capital Region.

Aerial view, Army Navy Drive/South Joyce Street (Google Maps)

Bus stop with shelter (klllane/Shutterstock)

Methods: From 2016 to 2020, Virginia experienced an average of 80 heat event days[v] per summer, resulting in 87 incremental heat-related ED visits and 21 incremental hospitalizations per heat event day.[vi] Each ED visit costs about $750 while each hospitalization costs roughly $15,000.[vii] This analysis converted state-level occurrences to bus stop-specific impacts using the population of Virginia (8.8 million)[viii] and ridership data (roughly 72 daily).[ix] These data imply an overall no-action cost of heat-related illness of roughly $3 daily stemming from this bus stop, and a per-summer cost of $244. The analysis assumes that this cost will grow annually by 3.6 percent based on regional climate data.[x] For the low-cost solution, the analysis assumes a purchase and installation cost of $33,000 for a bus shelter[xi] with an assumed maintenance cost of 5 percent annually ($1,650) and a 20-year useful life. For the high-cost solution, the analysis assumes additional vegetation costs of $2,000 (for 2-3 trees)[xii] with an annual maintenance cost of 10 percent ($200). Based on literature focused on lowering ambient temperatures,[xiii, xiv] the analysis assumes that the low-cost and high-cost solutions will prevent 10 percent and 20 percent of the annual no-action health costs ($24 and $48 per summer), respectively. Bus shelters are also assumed to generate roughly $11,500 in advertising revenue per year.[xv]

Detailed Results: Results indicate that the no-action scenario leads to roughly $7,000 in health impacts over a 20-year period. Proactive investment provides a health-savings over the same period of $700-$1,400 by lowering ambient temperatures. Advertising could generate an additional $230,000 in benefits over the 20-year useful life. The low-cost solution generates roughly $112,700 in net-benefits with a benefit-cost ratio (BCR) of 2.97, discounted at 3.1%. The high-cost solution generates roughly $108,200 in net-benefits with a BCR of 2.74, discounted at 3.1%.

Qualitative Benefits: The results presented above are conservative, and likely represent a lower bound for potential benefits and return on investment. Additional unmonetized benefits are expected to accrue from proactive investment. Heat events are also expected to result in increased ambulatory care responses (without hospital visits), but data were unavailable to monetize this impact. This analysis focuses on heat, but shelters and vegetation would also serve as wind and rain breaks, helping to minimize cold-related health impacts as well. Finally, this analysis does not monetize benefits from additional urban foliage (such as increased air quality, carbon sequestration, reduced stormwater runoff, or amenity values).

Regional Implications: There are many bus stops in the National Capital Region with similar characteristics to the Army Navy Drive and South Joyce Street stop: locations served by WMATA and other agencies that are unsheltered and susceptible to the elements and at risk of high temperatures. Between June and August of 2024, the average bus ridership for WMATA lines was over 300,000 per day while the average daily ridership for Arlington Transit for the same period was over 170,000. If transit agencies in the National Capital Region added shelters or shelters and vegetation to current bus stops serving even just 10% of these 470,000 bus riders, the health impact savings to the region could range from about $495,000 to $822,000 (discounted at 3.1%) over 20 years.

[i] Woolf, S., Morina, J., French, E., Funk, A., Sabo, R., Fong, S., Hoffman, J., Chapman, D., & Krist, A. (2024). The health care costs of extreme heat. Center for American Progress. https://www.americanprogress.org/article/the-health-care-costs-of-extreme-heat/

[ii] Sun Tran (2024). Heat Resiliency at Sun Tran Bus Stops. Sun Tran. https://www.suntran.com/wp-content/uploads/2024/05/Heat-Resilient-Bus-Stops-Case-Study.pdf

[iii] Lanza, K., Ernst, S., Watkins, K., & Chen, B. (2025). Heat stress mitigation by trees and shelters at bus stops. Transportation Research Part D: Transport and Environment. 140: 104653 https://doi.org/10.1016/j.trd.2025.104653

[iv] A discount rate is a rate used to determine the present value of future cash flows. As of 2025, the U.S. Department of Transportation recommends a discount rate of 3.1%.

[v] Heat event days are days that meet the criteria for “dry tropical” or “moist tropical” climatic conditions under the Spatial Synoptic Classification System. https://sheridan.geog.kent.edu/ssc3.html

[vi] Woolf, S., Morina, J., French, E., Funk, A., Sabo, R., Fong, S., Hoffman, J., Chapman, D., & Krist, A. (2024). The health care costs of extreme heat. Center for American Progress. https://www.americanprogress.org/article/the-health-care-costs-of-extreme-heat/

[vii] *Ibid.*

[viii] U.S. Census Bureau. (2024). QuickFacts: Virginia. U.S. Census Bureau. Retrieved April 2, 2025, from https://www.census.gov/quickfacts/fact/table/VA/PST045224

[ix] WMATA/ART official internal data, accessed by TPB via data request.

[x] NOAA. (n.d.). NOWData – NOAA Online Weather Data. National Weather Service. https://www.weather.gov/wrh/Climate?wfo=lwx

[xi] Duncan, I. (2022). Nation’s neglected bus stops pose early test for infrastructure money. The Washington Post. https://www.washingtonpost.com/transportation/2022/05/06/bus-shelters-riders-infrastructure/

[xii] Koppel, E. (2024). Thinking About Trees as an Investment. Casey Trees. https://caseytrees.org/2024/12/how-much-does-it-cost-to-plant-a-tree/

[xiii] Sun Tran (2024). Heat Resiliency at Sun Tran Bus Stops. Sun Tran. https://www.suntran.com/wp-content/uploads/2024/05/Heat-Resilient-Bus-Stops-Case-Study.pdf

[xiv] Lanza, K., Ernst, S., Watkins, K., & Chen, B. (2025). Heat stress mitigation by trees and shelters at bus stops. Transportation Research Part D: Transport and Environment. 140: 104653 https://doi.org/10.1016/j.trd.2025.104653

[xv] Lakatos, S. (2024). How DC’s bus shelters can better serve riders who need them most. Greater Washington. https://ggwash.org/view/93844/how-can-dcs-bus-shelters-better-serve-riders-who-need-them-the-most