Transportation Forestry as an Interdisciplinary Field for Urban Sustainability

Matthew H. E. M. Browning[a*^~], Ray Yeager[b*^~], Pamela Murray-Tuite[c], Lara Browning[d], Mashrur Chowdhury[c], Chien-Fei Chen[e], David R. Coyle[f], Monika M. Derrien[g], Angel M. Dzhambov[h,i,j], Theodore S. Eisenman[k], Chao Fan[c], Richard J. Hauer[l,m], Haneen Khreis[n], Fu Li[a], Lauren Marshall[o], Olivia McAnirlin[a], Ariane Middel[p], Mark Nieuwenhuijsen[q], Matthew Nicolette[d], Alessandro Rigolon[r], Jennifer Ogle[c], Alessandro Ossola[s], Nilesh Timilsina[f], Katie M. Thurson[a], David L. White[a], Kuiran Zhang[a], Kathleen L. Wolf[t*~]

[a] Department of Parks, Recreation & Tourism Management, Clemson University, Clemson, SC USA
[b] Division of Environmental Medicine, Department of Medicine, University of Louisville, Louisville, KY, USA
[c] Glenn Department of Civil Engineering, Clemson University, Clemson, SC USA
[d] College of Architecture, Art and Construction, Clemson University, Clemson, SC USA
[e] Department of Sociology, Anthropology and Criminal Justice, Clemson University, Clemson, SC, USA
[f] Department of Forestry & Environmental Conservation, Clemson University, Clemson, SC USA
[g] University of Vermont, Rubenstein School of Environment and Natural Resources, VT USA
[h] Research group "Health and Quality of Life in a Green and Sustainable Environment," Strategic Research and Innovation Program for the Development of MU – Plovdiv, Medical University of Plovdiv, Plovdiv, Bulgaria
[i] Environmental Health Division, Research Institute at Medical University of Plovdiv, Medical University of Plovdiv, Plovdiv, Bulgari
[j] Institute of Highway Engineering and Transport Planning, Graz University of Technology, Graz, Austria
[k] Department of Landscape Architecture and Regional Planning, University of Massachusetts Amherst, Amherst, MA USA
[l] Eocene Environmental Group, Des Moines, IA USA
[m] College of Natural Resources, University of Wisconsin – Stevens Point, Stevens Point, WI
[n] MRC Epidemiology Unit, School of Clinical Medicine, University of Cambridge, UK
[o] Arbor Day Foundation, Lincoln, NE, USA
[p] School of Arts, Media and Engineering, Arizona State University, Tempe, Arizona, USA
[q] Barcelona Institute for Global Health (ISGlobal), Barcelona, Spain
[r] Department of City & Metropolitan Planning, The University of Utah, Salt Lake City, UT, USA
[s] Department of Plant Sciences, University of California, Davis, CA, USA
[t] College of Built Environments, University of Washington, Seattle, WA USA

[^] co-first author
[~]authors contributed equally
[*] co-corresponding authors: mhb2@clemson.edu, kwolf@uw.edu, ray.yeager@louisville.edu

Abstract

Trees and vegetation provide extensive societal benefits, as do transportation systems that connect people with essential needs and services. Yet transportation infrastructure also concentrates heat, pollution, and noise. Integrating forestry with transportation systems has myriad benefits, but most communities cannot realize these benefits due to challenges in communication and integration across professional disciplines. We propose Transportation Forestry as a new subfield to unlock the full potential of nature-based solutions within transportation systems, enabling extensive and equitable benefits for environmental quality, human health, and sustainability. We outline the necessary approaches to research, practice, and training for deliberately integrating trees and vegetation into transportation infrastructure.

1. Introduction

Transportation systems play critical roles in cities, enabling safe travel for work, healthcare, education, and daily life[1]. These systems cover up to 20% of urban land globally but impose disproportionate sustainability burdens[2,3]. Pavement contributes to urban heat islands[4], while traffic generates harmful emissions and noise[5,6]. Combined with extensive parking, roads foster car cultures that minimize active mobility, landscape connectivity, and community cohesion[7].

We envision a radically different future: making trees a prominent component of transportation systems. Trees and green infrastructure offer efficient solutions to climate change, biodiversity loss, pollution, social isolation, and physical inactivity[8–12]. Despite decades of recognition that vegetation can mitigate transportation harms[13], progress remains limited. Current approaches fragment across disciplines; urban foresters lack transportation expertise, traffic engineers rarely consider ecological functions, and public health professionals often work in isolation[1,14–16]. This siloed approach perpetuates suboptimal systems[17].

We propose Transportation Forestry as a dedicated new transdisciplinary subfield. Below we (i) define its scope, (ii) summarize benefits, and (iii) outline equity, research, and workforce needs.

2. Orienting Transportation Forestry within Urban & Community Forestry

Urban and community forestry (U&CF) emerged in the 1960s to address urban forest management and community needs[18]. U&CF now drives urban green infrastructure development across cities, suburbs, and rural communities, managing trees and supporting infrastructure in public and private spaces[19].

Applying U&CF along transportation corridors requires distinct expertise[20]. Beyond ecological knowledge of species suitability, soil science, and hydrology, practitioners need advanced understanding of transportation systems to optimize context-specific benefits. Commercial districts may prioritize shade and aesthetics for walkability, while residential areas balance these with safety considerations. Specialized knowledge addresses traffic management, root-pavement interactions, species suited to harsh conditions, air quality complexities, and visibility requirements[9,21–24]. Since urban tree plantings concentrate along streets and active transportation facilities, opportunities also exist to better integrate species selection with transportation and civil engineering.

A subfield of U&CF, Transportation Forestry would be the research and practice of deliberately integrating living vegetation with transportation infrastructure for societal benefit. This intentionally broad definition applies to diverse facility types and settlement contexts. Achieving

full benefits requires contextual understanding integrated with U&CF, transportation, and public health expertise.

Transportation Forestry would apply to nearly any physical infrastructure facilitating movement of people and goods. Roads and streets are particularly relevant, comprising outsized portions of urban land and contributing substantially to environmental health burdens[25]. These span from highways to local streets and integrate with transit, parking, sidewalks, and bicycle infrastructure[26]. While the principles we propose here primarily address roadways and active transportation, they broadly apply to other sectors as well[10].

Transportation Forestry would be a systems approach extending beyond trees. Green infrastructure spans the rural-urban continuum[26], from landscapes in suburban areas to assemblages emulating ecological functions in dense urban settings, including green walls and roofs, bioretention systems, permeable pavings, and heat-reduction plantings.

We envision Transportation Forestry as integrating multiple disciplines for proactive design and implementation that maximizes sustainability, safety, and co-benefits (**Figure 1**). It consolidates considerations of siting, selection, maintenance, and anticipated effects while emphasizing community collaboration to address environmental injustices. Integration across U&CF, landscape architecture, natural sciences, urban planning, and the broad array of social sciences provides guidance on species suitability, ecosystem and community effects, resident stewardship and ownership, policy alignment, and long-term sustainability.

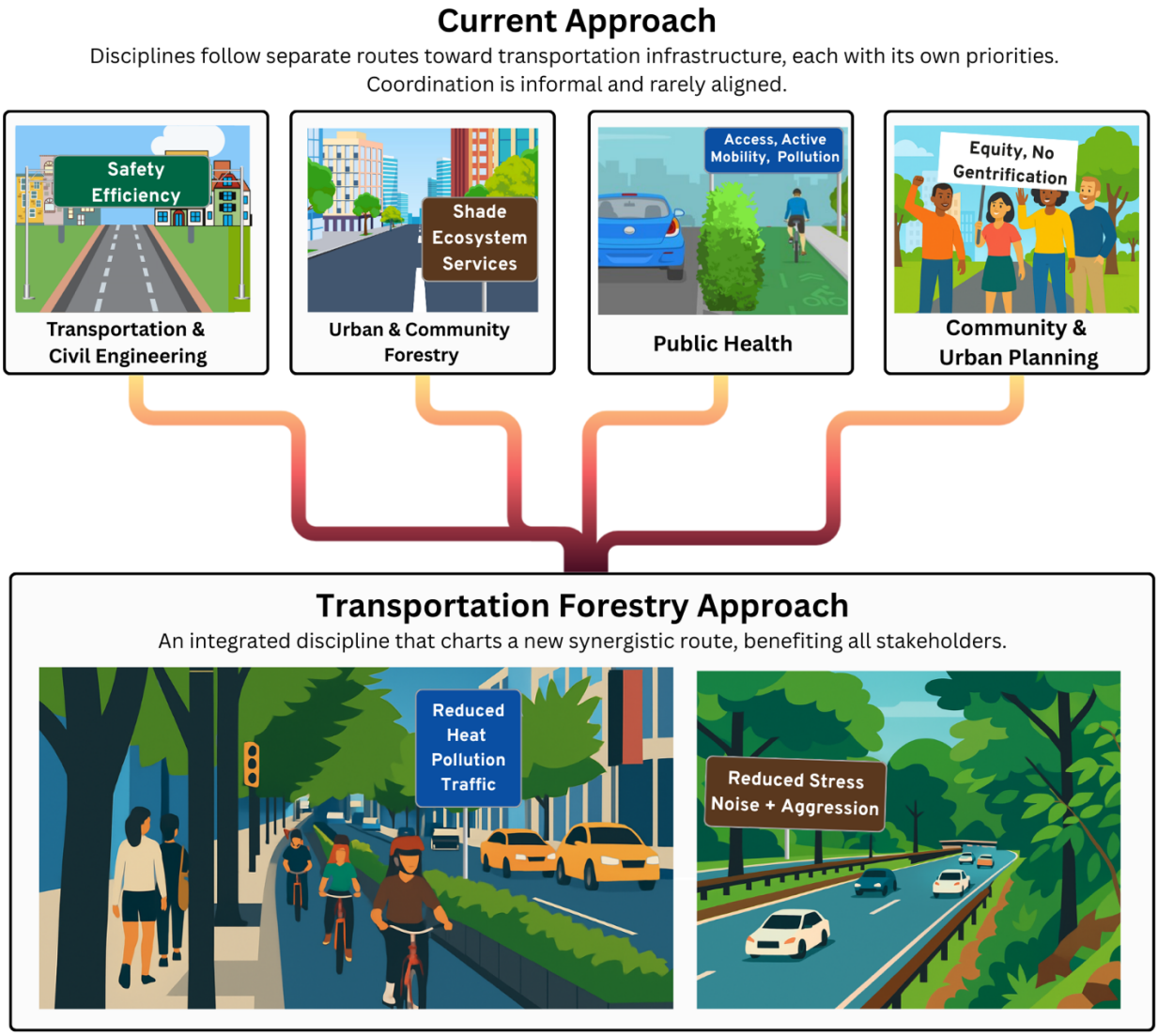

Figure 1. Transportation Forestry merges disciplines and approaches that typically work independently toward separate priorities

Successful implementation of Transportation Forestry will require incorporating best practices across divergent disciplines and approaches. For instance, utility arboriculture is required to provide expertise on pruning and rights-of-way safety. Transportation and urban planning is required to offer frameworks for incorporating green spaces. Civil and transportation engineering is required to design safe geometries while minimizing sight line and clear zone concerns. Landscape architecture is required create planting plans addressing stormwater, air quality, noise, and place-making goals.

Beyond physical implementation disciplines, social, behavioral, and health sciences are required for Transportation Forestry. Expertise from environmental and public health researchers is required to clarify how vegetation generates cumulative health co-benefits. Community development experts are required to ensure authentic resident participation. Environmental

justice scholars are needed to address how green infrastructure effects intersect with concentrated disadvantage, environmental stressors, and gentrification-related displacement.

4. Why a New Sub-Field?

Hoping for these divergent disciplines and approaches to better communicate and collaborate is insufficient. A new sub-field is critical for change. Issues related to U&CF and transportation systems have been recognized for decades, conversations among necessary professionals remain fragmented[14–16]. With clear needs but sparse successes, establishing Transportation Forestry offers a new approach to drive action at scale.

The potential impact simply cannot emerge from supplementing existing fields. It requires deeply integrating disparate knowledge into coherent, broadly applicable policy, research, and practice. If successful, Transportation Forestry will bolster resources for foresters and engineers; increase policymaker awareness; establish widely adoptable best practices for transportation agencies; and better integrate environmental health principles. This paradigm advances urban forestry beyond existing silos into domains with largely unrealized potential.

A transdisciplinary approach is also essential for context-dependent design. Highways generating high pollution burdens can optimally benefit from dense plantings allowing sight lines and airflow. Local roads generating lower burdens may incorporate interspersed canopy and shrubs for shade, aesthetics, and public green spaces benefiting mental health and physical activity. Weighing trade-offs and combining field-specific knowledge requires this new subfield to consolidate tools and disciplines at scale.

5. Benefits of Establishing Transportation Forestry

Roadway Safety

Safety will be paramount in Transportation Forestry. Nearly 1.35 million people die annually in road crashes worldwide[27], among the top ten causes of death globally[28]. Millions more are seriously injured[29]. Vision Zero policies aim to end traffic fatalities through systemic approaches requiring policy review and innovation.

Transportation engineering has historically emphasized clear zones free of fixed objects, including trees, on high-speed roads. However, research suggests clear zone policies should reflect specific situations rather than universal application. While transportation leaders may recognize vegetation benefits, this understanding may not overcome perceived safety concerns in widely accepted design standards[15].

Trees offer several safety enhancing opportunities. Impact speed is particularly important, since fatality risk at 60 km/h is five times higher than at 30 km/h[30]. Roadside trees correlate with traffic-calming and reduced speeding[10] through visual friction reinforcing posted speeds[31]. Research also shows increased driver attention and shorter reaction times with roadside greening[32]. Trees spaced closer together influence vehicle position, moving drivers farther from road edges[33]. And U.S. crash data for urban settings indicate lower death and injury rates when trees are present[16].

Safety-conscious Transportation Forestry will likely incorporate frangible (pliable) plantings that buffer impact energy, reducing overall injury and fatality rates. By contrast, the lack of vegetation can unintentionally increase speeds, exacerbate driver error, and reduce safety[31].

Transportation Burdens

Roadway traffic is a primary pollution source in many cities[6], emitting harmful noise[5] and contributing to urban heat islands and flooding through extensive impervious surfaces[4].

Appropriately designed vegetation along highways can cost-effectively reduce traffic pollution exposure, blocking and filtering pollutants from residential areas (**Figure 2**). However, in dense urban street canyons, vegetation can impede air mixing, reducing pollution dispersion[34]. Some trees reduce air quality through allergenic pollen and biogenic volatile organic compounds[23]. Furthermore, transportation is a substantial driver of climate change[35], as nearly 20% of all worldwide carbon dioxide emissions worldwide are sourced from the transportation sector[36]. Transportation Forestry requires design solutions maximizing pollution reduction while avoiding unintended consequences. Trees also effectively reduce roadway noise[37], but deliberate design and species selection is needed to observe the maximum benefits[38].

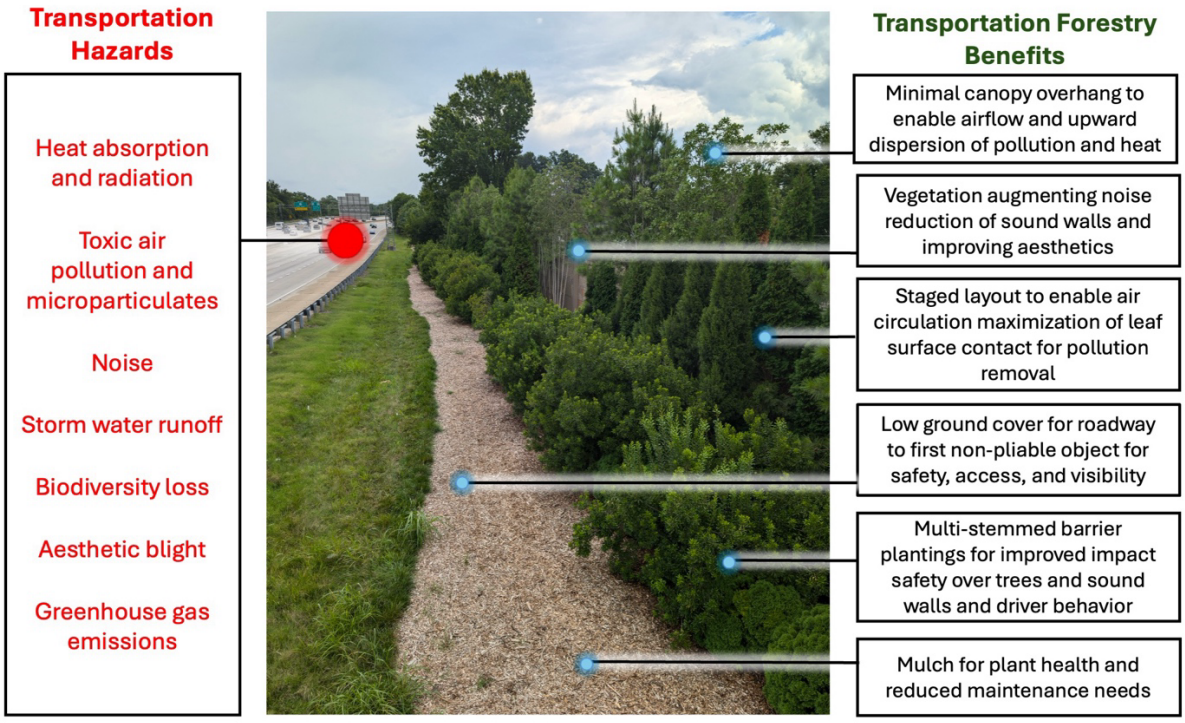

Figure 2. Green Heart Louisville is an example of Transportation Forestry infrastructure installed on high-speed roads. (Image courtesy of the authors).

Health Promotion

Beyond mitigating transportation burdens, Transportation Forestry improves health in multiple ways. Green neighborhoods associate with lower blood pressure and reduced incidence cardiovascular disease worldwide[12]. High tree canopy and vegetation cover also correlate with improved sleep, birth outcomes, physical activity, and reduced chronic disease and mortality[12]. Vegetation along corridors facilitates social connections through aesthetics, cooling, and ecosystem services, increasingly recognized as crucial to wellbeing[39].

Meanwhile, rising obesity and physical inactivity increasingly drive global disease burden. Transportation Forestry facilitates active travel with wide-ranging implications for population-wide physical activity and social interaction, improving access to healthy goods and services, especially for those with limited transportation options[40].

Urban forests along transportation corridors also benefit residents' physical and mental health[10,13]. Transportation spaces dominate the public sphere, profoundly determining physical activity, mental health, and social connection. Transportation-integrated greenspaces likely improve social connection quality through cognitive function, lowered aggression, and improved affect[41,42]. Resident engagement as stewards may also promote social cohesion, pride, and community attachment.

Forestry provides numerous indirect co-benefits as well. Greened vacant lots near roadways associate with reduced crime and improved mental health[43]. Public health guidance increasingly acknowledges pedestrian and bicycling mobility importance for health and climate[44]. Transportation Forestry entails selecting the sites and species providing shade for active transportation users while minimizing safety concerns.

Ecosystem Services

Given transportation facilities' outsized public presence, ecosystem service potential extends beyond health benefits and burden mitigation. Transportation-adjacent trees provide cultural services: therapeutic landscapes near healthcare facilities, educational opportunities near schools, and aesthetic contributions symbolizing place[45], which can improve merchant revenues through aesthetic and comfortable shopping environments[46].

Ecological functions yield additional services of Transportation Forestry. Well-designed roadside landscapes reduce maintenance costs for mowing, invasive species management, and trash control while cost-effectively addressing flooding and stormwater runoff. Trees also intercept rainfall, improve infiltration, and prevent erosion[47]. Transportation Forestry could also leverage less common endemic spaces to promote biodiversity.

More broadly, trees represent a potent nature-based climate solution. Impervious surfaces drive urban heat islands, and vegetation provides uniquely effective, cost-effective cooling. Urban heat causes the highest climate-related disaster deaths[48], disproportionately affecting underserved communities[49]. Vegetation counters this through shading and evapotranspiration, mitigating climate-driven morbidity and mortality.

Equity

However, transportation burdens are inequitably distributed to disadvantaged communities, exacerbating preexisting inequities. Transportation-related politics and policies have caused disadvantages across communities from road placement externalities to direct environmental harms, reinforcing longstanding divides[50]. Underserved communities near major corridors may benefit more from nature-based interventions; residents lacking mobility options spend more time locally, suffer greater cumulative environmental burdens, and have lower baseline health[51]. Many cities now adopt holistic greenspace equity goals, including the "3-30-300 rule" (three visible trees per dwelling, 30% neighborhood canopy, greenspace within 300 meters)[52].

Another equity consideration involves unsheltered populations. Green spaces near transportation corridors, commonly accessible to this population, may encourage encampment occupancy with

associated health implications from air quality, noise, and heat exposure[53]. Encampment-related vegetation damage may increase maintenance costs, while nearby residents may object, weakening support for initiatives. Transportation Forestry must address homelessness complexities to reduce vulnerable population exposures and enable successful implementation.

6. Actions to Establish Transportation Forestry

To realize Transportation Forestry's potential, we propose several actionable next steps. We call for comprehensive policies reflecting best available evidence and integrating arboriculture, horticulture, and landscape architecture with traditional transportation policies. Proactive integration into new transportation projects, which will greatly lower the implementation and maintenance costs compared to retrofitting. Furthermore, expansion and alteration of facilities is a continuous process, which offers ample and ongoing opportunities for integration of Transportation Forestry. Integrated governance between U&CF, DOTs, public health, planning, and affected communities is ultimately necessary for effective, equitable collaboration and efficient economies of scale.

Updating Policy and Planning. Transportation policy agencies maintain best practices and standards spanning from parcels to nations through complex, multi-volume documents[54–56]. These systems command large capital investments, making policy and economic investment in roadside trees more time sensitive. Transportation recommendations are evidence-based from active research communities. Yet rapidly expanding science about urban trees hasn't adequately intersected with transportation guidance. Roadside vegetation receives modest attention, perceived as aesthetic backdrop or safety hazard[15]. Recent multidimensional research indicates mobility system policies should integrate trees for sustainability goals[14]. Nature elements must be included in project planning from earliest stages, with dedicated budgets deemed essential to the projects, to ensure they are integrated within the gray infrastructure for optimal functioning.

Multi-Sectoral Financing Approaches. Multi-sectoral financing strategies are needed to activate and achieve the full benefits of Transportation Forestry. Despite the documented benefits, planners may not consider Transportation Forestry mission-critical or cost-effective, despite extensive net savings across sectors. Few transportation agencies, health professionals, or insurers prioritize transportation-integrated greening for population health. Economic analyses that account for the cost savings of Transportation Forestry across health, housing, disaster resilience, and environmental quality sectors are needed to enable financing and widespread implementation.

Environmental Justice and Equity.Reducing transportation burdens and addressing systematic injustices is central to Transportation Forestry's rationale. We call for focused, community-engaged practice in communities experiencing highest transportation harms and greatest potential benefits. Areas with lowest socioeconomic status tend to have lowest tree canopy[57]. Greening initiatives in disadvantaged communities often experience low adoption, maintenance, and survival rates, compounded by limited planting space. This confluence highlights the need for deliberate, context-tailored investments in plantable public spaces within transportation systems, considering procedural, recognitional, and distributional factors[58]. More work is needed exploring complex considerations across scales and root causes. While many stakeholders lack power under existing systems, quantifiable benefits across fields enable parties beyond U&CF to implement Transportation Forestry with equitable co-benefits.

Education and Workforce Development. We call for developing interdisciplinary professional education and workforce programs promoting broader communication and knowledge transfer. Leadership is needed to develop this transdisciplinary expertise, creating trust and conversations between disciplines and agencies with little current overlap. Integrated curricula can span undergraduate and graduate courses, cross-listed across departments. Coordinated materials and case studies are needed to address disciplinary-specific challenges. Experts can co-develop training modules ensuring trainees learn from critical sectors. Certificates can serve distance learners and professionals seeking continuing education. Professional organizations such as the Transportation Research Board, NACTO, ASLA, Urban and Community Forestry Society could pursue accreditation standards.

Research Needs. We also call for increased research developing evidence-based best practices in Transportation Forestry. While U&CF research grows steadily, specific research on trees and transportation is limited. Essential topics include:

1. **Safety and crashes**: Few articles consider road safety when evaluating street tree benefits[13]. Conversely, transportation research emphasizes trees as safety risks, rarely acknowledging community benefits. Rectifying these perspectives across contexts is critical. Current crash data may not fully reflect local conditions[16]. "Safe System" approaches could balance physical constraints with driver cognition[59], while crash taxonomies could inform avoidance countermeasures[60].
2. **Public health benefits**: Despite growing greenspace-health literature, most cannot inform practice due to vague definitions and measures of nature or greenspace[61,62], inadequate results from experimental and implementation research[43], and ultimately limited generalizability. Transportation Forestry approaches should synthesize evidence across fields. Directed research holds promise for improving benefits and advancing nature-health research broadly.
3. **Landscape context and multiple modes**: Future work must explore trees in airports, rail yards, ports, and rail lines where research is less established. Collaborative perspectives on mobility types and emerging technologies are essential. Evaluating existing tools—Context Sensitive Solutions, Complete Streets, NACTO guidelines, Woonerf design, shared space strategies, Manual for Streets—could inform adaptation. International guidelines like China's Urban Road Greenery Design Standards and Street Design Guidelines merit evaluation[63].
4. **Vegetation and safety intersections**: Beyond reduced access, little is known about roadside greenery contexts and driver behavior implications. Research on green infrastructure quantities and qualities could balance climate, environment, transportation, and policy constraints. Technologies like autonomous vehicles with sensors and AI algorithms may enable scalable, cost-effective monitoring and analysis. Tradeoffs between solar infrastructure and tree planting may increase with infrastructure investments.
5. **Tree growth challenges**: Root-pavement interactions create hazards and maintenance costs. Technologies like ground-penetrating radar enable forensic evaluation and preventive repairs. Growing practice and research will expand species selection knowledge minimizing pavement damage. International Society of Arboriculture offers important guidance.

6. **U&CF and DOT collaboration**: Routine updates of best practices, training, ordinances, and policies will support Transportation Forestry, requiring input from U&CF and DOTs to establish nationally and locally relevant practices. Focus groups and case studies of effective collaboration would highlight techniques and communication approaches. Findings can integrate into practice standards. "Road ecology" emerged as multidisciplinary framework elevating fragmented knowledge into inclusive solutions for ecological corridors[64]. In China, transport departments collaborate with landscape experts from early planning stages, with landscape architects designing comprehensive features. Cross-cultural investigations are needed on U&CF-transportation practices in China and their translatability[65]. Transportation Forestry may benefit from road ecology's development challenges and successes.
7. **Expanding to other transportation forms**: Benefits beyond roads remain underexplored. Rail lines, light rail, and airports present greening opportunities. Trees along rail corridors could reduce passenger and conductor stress; airport greening may improve traveler wellbeing and buffer noise. These may parallel road benefits but require research determining translation and unique challenges.
8. **Adapting transportation around green infrastructure**: Most framing addresses sustainable installation where infrastructure exists. A paradigm shift would build transportation corridors around existing or desired green infrastructure through new planning, ordinances, and design systems.

7. Conclusion

Establishing Transportation Forestry provides a new approach addressing complex urban challenges across diverse contexts. Evidence-based policy and consistent budgeting from national to local scales are crucial foundations. Implementation will provide extensive co-benefits to urban sustainability, biodiversity, public health, and wellbeing. Developing necessary collaborations, tools, and workforces will result in healthier, more livable urban communities worldwide.

Acknowledgments

Ray Yeager's contribution to this work was supported by funding from the National Institutes of Health (NIEHS R01 ES029846, P42 ES023716, P30 ES030283) and the Owsley Brown II Family Foundation. Angel M. Dzhambov's contribution to this work is supported by the "Strategic research and innovation program for the development of Medical University – Plovdiv" No. BG-RRP-2.004-0007-C01, Establishment of a network of research higher schools, National plan for recovery and resilience, financed by the European Union – NextGenerationEU. Alessandro Ossola is supported by USDA-NIFA (CA-D-PLS-2735-H). We are grateful for Caroline Henderson in the Clemson University School of Architecture for her assistance with the figures.

References

1. Glazener, A. *et al.* Fourteen pathways between urban transportation and health: A conceptual model and literature review. *Journal of Transport & Health* **21**, 101070 (2021).

2. Angel, S. & Blei, A. M. Monitoring the Share of Land in Streets. in *Land and the City* (ed. G W McCarthy, G. K. I., S. A. Moody) (2015).
3. Guerra, E., Duranton, G. & Ma, X. Urban Roadway in America: The Amount, Extent, and Value. *J. Am. Plan. Assoc.* **91**, 102–116 (2025).
4. Frazer, L. Paving Paradise: The Peril of Impervious Surfaces. *Environmental Health Perspectives* **113**, A456–A462 (2005).
5. Goines, L. & Hagler, L. Noise Pollution; A Modern Plague. *Southern Medical Journal* **100**, 287–294 (2007).
6. Mayer, H. Air pollution in cities. *Atmospheric Environment* **33**, 4029–4037 (1999).
7. Sheller, M. & Urry, J. The City and the Car. *Int. J. Urban Reg. Res.* **24**, 737–757 (2000).
8. Wolf, K. L. *et al.* Urban Trees and Human Health: A Scoping Review. *International Journal of Environmental Research and Public Health* **17**, 4371–30 (2020).
9. Treese, J. W. V., Koeser, A. K., Fitzpatrick, G. E., Olexa, M. T. & Allen, E. J. A review of the impact of roadway vegetation on drivers' health and well-being and the risks associated with single-vehicle crashes. *Arboricultural Journal* **39**, 179–193 (2017).
10. Eisenman, T. S., Coleman, A. F. & LaBombard, G. Street Trees for Bicyclists, Pedestrians, and Vehicle Drivers: A Systematic Multimodal Review. *Urban Science* **5**, 56 (2021).
11. Nieuwenhuijsen, M. J., Khreis, H., Triguero-Mas, M., Gascon, M. & Dadvand, P. Fifty shades of green. *Epidemiology* **28**, 63–71 (2017).
12. Yang, B.-Y. *et al.* Greenspace and human health: An umbrella review. *The Innovation* **2**, 100164 (2021).

13. Coleman, A. F., Harper, R. W., Eisenman, T. S., Warner, S. H. & Wilkinson, M. A. Street Tree Structure, Function, and Value: A Review of Scholarly Research (1997–2020). *Forests* **13**, 1779 (2022).
14. White, E. O. Daylighting decision-making at state departments of transportation: A case study of roadside tree removal. *Transportation Research Interdisciplinary Perspectives* **28**, 101255 (2024).
15. White, E. O. Unclear territory: Clear zones, roadside trees, and collaboration in state highway agencies. *Transportation Research Part D: Transport and Environment* **118**, 103650 (2023).
16. Wolf, K. & Bratton, N. Urban Trees and Traffic Safety: Considering U.S. Roadside Policy and Crash Data. *Arboriculture & Urban Forestry* **32**, 170–179 (2006).
17. World Health Organization. Urban green spaces and health: A review of evidence. https://iris.who.int/server/api/core/bitstreams/74006ead-650d-4fca-815a-f1ff53c1eea1/content (2016).
18. Johnston, M. A Brief History of Urban Forestry in the United States. *Arboricultural Journal* **20**, 257–278 (1996).
19. Konijnendijk, C. C., Ricard, R. M., Kenney, A. & Randrup, T. B. Defining urban forestry – A comparative perspective of North America and Europe. *Urban Forestry & Urban Greening* **4**, 93–103 (2006).
20. OHerrin, K., Wiseman, P. E., Day, S. D. & Hauer, R. J. Professional identity of urban foresters in the United States. *Urban Forestry & Urban Greening* 126741 (2020) doi:10.1016/j.ufug.2020.126741.
21. Roman, L. A. *et al.* Beyond 'trees are good': Disservices, management costs, and tradeoffs in urban forestry. *AMBIO* **21**, 1–16 (2020).

22. Ossola, A. *et al.* Research note: Integrating big data to predict tree root blockages across sewer networks. *Landscape and Urban Planning* **240**, 104892 (2023).
23. Barwise, Y. & Kumar, P. Designing vegetation barriers for urban air pollution abatement: a practical review for appropriate plant species selection. *npj Climate and Atmospheric Science* **3**, 12 (2020).
24. Eisenman, T. S. *et al.* Urban trees, air quality, and asthma: An interdisciplinary review. *Landscape and Urban Planning* **187**, 47–59 (2019).
25. Melosi, M. V. The Automobile Shapes The City: The“Footprint”of the Automobile on the American City. (2010).
26. Rouse, D. C. & Bunster-Ossa, I. F. *Green Infrastructure: A Landscape Approach*. (2013).
27. Ahmed, S. K. *et al.* Road traffic accidental injuries and deaths: A neglected global health issue. *Health Science Reports* **6**, e1240 (2023).
28. James, S. L. *et al.* Morbidity and mortality from road injuries: results from the Global Burden of Disease Study 2017. *Inj Prev* **26**, i46–i56 (2020).
29. Prevention\textbackslashtextasciitilde, Centers for Disease Control and. Road Traffic Injuries and Deaths—A Global Problem. (2023).
30. Hussain, Q., Feng, H., Grzebieta, R., Brijs, T. & Olivier, J. The relationship between impact speed and the probability of pedestrian fatality during a vehicle-pedestrian crash: A systematic review and meta-analysis. *Accident Analysis & Prevention* **129**, 241–249 (2019).
31. Gargoum, S. A., El-Basyouny, K. & Kim, A. Towards setting credible speed limits: Identifying factors that affect driver compliance on urban roads. *Accident Analysis & Prevention* **95**, 138–148 (2016).

32. Chiang, Y.-C., Ke, R.-A., Li, D. & Weng, P.-Y. Greening and Safety: The Influence of Road Greenness on Driver's Attention and Emergency Reaction Time. *Environment and Behavior* 001391652211476 (2022) doi:10.1177/00139165221147627.
33. Calvi, A. Does Roadside Vegetation Affect Driving Performance?: Driving Simulator Study on the Effects of Trees on Drivers' Speed and Lateral Position. *Transportation Research Record* **2518**, 1–8 (2015).
34. Deshmukh, P. *et al.* The effects of roadside vegetation characteristics on local, near-road air quality. *Air Quality, Atmosphere & Health* **12**, 259–270 (2019).
35. Slimi, K., Chrouda, A. & Öztop, H. F. Traffic effects on global warming: A review. *Renewable and Sustainable Energy Reviews* **226**, 116248 (2026).
36. Azhar, U., Yaseen, S., Arif, M., Babar, M. & Sagir, M. Emission of greenhouse gases from transportation. in *Advances and Technology Development in Greenhouse Gases: Emission, Capture and Conversion* 147–163 (Elsevier, 2024). doi:10.1016/B978-0-443-19231-9.00016-8.
37. Renterghem, T. V. & Botteldooren, D. Numerical evaluation of tree canopy shape near noise barriers to improve downwind shielding. *The Journal of the Acoustical Society of America* **123**, 648–657 (2008).
38. Renterghem, T. V., Forssén, J., Attenborough, K. & Acoustics, P. J. A. Using natural means to reduce surface transport noise during propagation outdoors. *Landscape and Urban Planning* **92**, 86–101 (2015).
39. Holt-Lunstad, J. Social connection as a critical factor for mental and physical health: evidence, trends, challenges, and future implications. *World Psychiatry* **23**, 312–332 (2024).

40. Yu, J., Zhang, H., Dong, X. & Shen, J. The impact of street greenery on active travel: a narrative systematic review. *Frontiers in Public Health* **12**, (2024).

41. Kuo, F. & Sullivan, W. C. Aggression and violence in the inner city: Effects of environment via mental fatigue. *Environment and Behavior* **33**, 543–571 (2001).

42. Berman, M. G., Jonides, J. & Kaplan, S. The cognitive benefits of interacting with nature. *Psychological Science* **19**, 1207–1212 (2008).

43. Fry, D. *et al.* The Effect of Place-Based Nature Interventions on Human Health: A Systematic Review. *Environmental Research* 123157 (2025) doi:10.1016/j.envres.2025.123157.

44. Officials\textbackslashtextasciitilde, N. A. of C. T. *Urban Street Design Guide*. (Island Press, 2013).

45. Phillips, C., Straughan, E. & Atchison, J. Gratitude for and to nature: insights from emails to urban trees. *Social & Cultural Geography* **25**, 363–384 (2024).

46. Wolf, K. L. Business District Streetscapes, Trees, and Consumer Response. *Journal of Forestry* **103**, 396–400 (2005).

47. Pallathadka, A., Sauer, J., Chang, H. & Grimm, N. B. Urban flood risk and green infrastructure: Who is exposed to risk and who benefits from investment? A case study of three U.S. Cities. *Landscape and Urban Planning* **223**, 104417 (2022).

48. Bowler, D. E., Buyung-Ali, L. M., Knight, T. M. & Pullin, A. S. Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning* **97**, 147–155 (2010).

49. Jesdale, B. M., Morello-Frosch, R. & Cushing, L. The Racial/Ethnic Distribution of Heat Risk–Related Land Cover in Relation to Residential Segregation. *Environmental Health Perspectives* **121**, 811–817 (2013).

50. Archer, D. N. ‘White Men’s Roads Through Black Men’s Homes’*: Advancing Racial Equity Through Highway Reconstruction. *Vanderbilt Law Review* **73**, (2020).
51. Rigolon, A., Browning, M. H. E. M., McAnirlin, O. & Yoon, H. (Violet). Green Space and Health Equity: A Systematic Review on the Potential of Green Space to Reduce Health Disparities. *IJERPH* **18**, 2563 (2021).
52. Konijnendijk, C. Promoting health and wellbeing through urban forests – Introducing the 3-30-300 rule. *IUCN* (2021).
53. Land, S. R. & Derrien, M. M. Homelessness and nature across landscapes and disciplines: A literature review. *Landscape and Urban Planning* **255**, 105254 (2025).
54. National Highways. *Design Manual for Roads and Bridges*. (2020).
55. Austroads. *Guide to Road Design Part 3: Geometric Design (Edition 3.4)*. (2021).
56. AASHTO. *A Policy on Geometric Design of Highways and Streets, 7th Edition*. (2018).
57. Klompmaker, J. O. *et al.* Racial, Ethnic, and Socioeconomic Disparities in Multiple Measures of Blue and Green Spaces in the United States. *Environ Health Perspect* **131**, 017007 (2023).
58. Eisenman, T. S., Roman, L. A., Östberg, J., Campbell, L. K. & Svendsen, E. Beyond the *Golden Shovel*: Recommendations for a Successful Urban Tree Planting Initiative. *Journal of the American Planning Association* 1–11 (2024) doi:10.1080/01944363.2024.2330943.
59. Ewing, R. & Dumbaugh, E. The Built Environment and Traffic Safety. *Journal of Planning Literature* **23**, 347–367 (2009).
60. Khattak, A. J., Ahmad, N., Wali, B. & Dumbaugh, E. A taxonomy of driving errors and violations: Evidence from the naturalistic driving study. *Accident Analysis & Prevention* **151**, 105873 (2021).

61. Browning, M. H. E. M. *et al.* Establishing Consensus on Standardized Survey Measures of Time Outdoors in Nature. Preprint at https://doi.org/10.2139/ssrn.5583864 (2025).
62. Matthew H. E. M. Browning. Beyond exposure: Toward more precise terminology in nature and health research. Preprint at https://doi.org/doi.org/10.31234/osf.io/ekfxu_v1 (2025).
63. 上海市规划和国土资源管理局, 上海市交通委员会, 上海市城市规划设计研究院主编 =. *上海市街道设计导则 / SHANGHAI STREET DESIGN GUIDELINES / Shanghai Planning and Land Resource Administration Bureau, Shanghai Municipal Transportation Commission, Shanghai Urban Planning and Design Research Institute ed*. (同济大学出版社, Shanghai, 2016).
64. Forman, R. T. T. *Road Ecology: Science and Solutions*. (Island Press, Chicago, 2013).
65. 陈晓刚主编. & 陈晓刚. 风景园林规划设计原理. (中国建材工业出版社, Beijing, 2020).