Transportation Forestry as an Interdisciplinary Field for Urban Sustainability

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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 these two 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 are fragmented across disciplines; urban foresters lack transportation expertise, traffic engineers rarely consider ecological functions, and public health professionals often work in parallel, not lockstep, with these disciplines[1,14–16]. Such siloed approaches perpetuate suboptimal systems[17].

We propose Transportation Forestry as a dedicated new transdisciplinary subfield. In this perspective, we define its scope, review its benefits, and outline actions to establish it as a subfield: updating policy and planning, securing multi-sectoral financing, addressing environmental justice and equity, creating education and workforce development programs, and spurring several critical new lines of research. If successful, this will result in healthier, more livable urban communities worldwide.

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]. Yet applying U&CF along transportation corridors requires distinct expertise[20]. Specialized knowledge is needed to address traffic management, root-pavement interactions, species suited to harsh conditions, air quality complexities, and visibility requirements[9,21–24]. Ecological knowledge of species suitability, soil science, and hydrology is also required. To optimize context-specific benefits, information on zoning and site selection is needed. For example, commercial districts may prioritize shade and aesthetics for walkability, while residential areas balance these with safety considerations.

To train a workforce with this expertise, we define Transportation Forestry as the practice of deliberately integrating living vegetation with transportation infrastructure for societal and environmental benefit. This intentionally broad definition applies to diverse facility types and contexts. Correspondingly, the definition applies 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 also require a systems approach extending beyond trees. The green infrastructure leveraged by Transportation Forestry could span 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.

Correspondingly, Transportation Forestry requires integrating many different disciplines for its success (**Figure 1**). Notably, it would tackle considerations of siting, selection, maintenance, and anticipated effects while emphasizing community collaboration to address environmental injustices. It would lean heavily on U&CF, landscape architecture, urban planning, and the social sciences to ensure species suitability, ecosystem and community effects, resident stewardship and ownership, policy alignment, and long-term sustainability. But Transportation Forestry would also require expertise from utility arboriculture to provide expertise on pruning and rights-of-way safety; civil and transportation engineering to design safe geometries while minimizing sight line and clear zone concerns; and public health to ensure active mobility, access, and air and noise pollution are addressed. Importantly, community and environmental justice scholars are needed to address how green infrastructure effects intersect with concentrated disadvantage, environmental stressors, unsheltered populations, and gentrification-related displacement.

3. Why a New Subfield?

We outline four reasons why establishing Transportation Forestry as a subfield is critical.

Relying on existing disciplines to organically coordinate more effectively is unrealistic. Such coordination has been ineffective outside of isolated examples over the past several decades. Instead, transportation systems are governed by entrenched hierarchies, processes, policies, and funding streams that are overwhelmingly centered within transportation agencies in many developed countries. Although the need to better integrate U&CF, public health, and ecological expertise into transportation planning has been recognized for decades, progress has remained fragmented and incremental[14–16].These disciplines operate under different mandates, incentives, and cultures, and collaboration is typically ad hoc. Without a dedicated subfield, transportation decisions will continue to default toward mobility and safety alone, with trees and green infrastructure treated as secondary (or tertiary) considerations.

Transportation Forestry reflects a natural evolution of professional specialization in response to increasing complexity and societal need. Many professional fields begin with generalized knowledge and practices and later differentiate into subfields as evidence accumulates, contexts change, and problems become more complex. A notable example is the branching of ecology into numerous subfields, from evolutionary ecology to landscape and spatial ecology, conservation ecology, and more[27]. Historically, transportation systems were designed to address physical mobility and safety; today, they are also central to climate adaptation, public health equity, biodiversity conservation, and social well-being[1]. Urban contexts have evolved rapidly, but transportation policies and design frameworks have arguably not kept pace. As a result, trees and green infrastructure are often introduced late in the planning process, rather than as core design elements. The establishment of a dedicated Transportation Forestry subfield would create the specialized expertise and value statement to integrate trees into transportation systems from the outset.

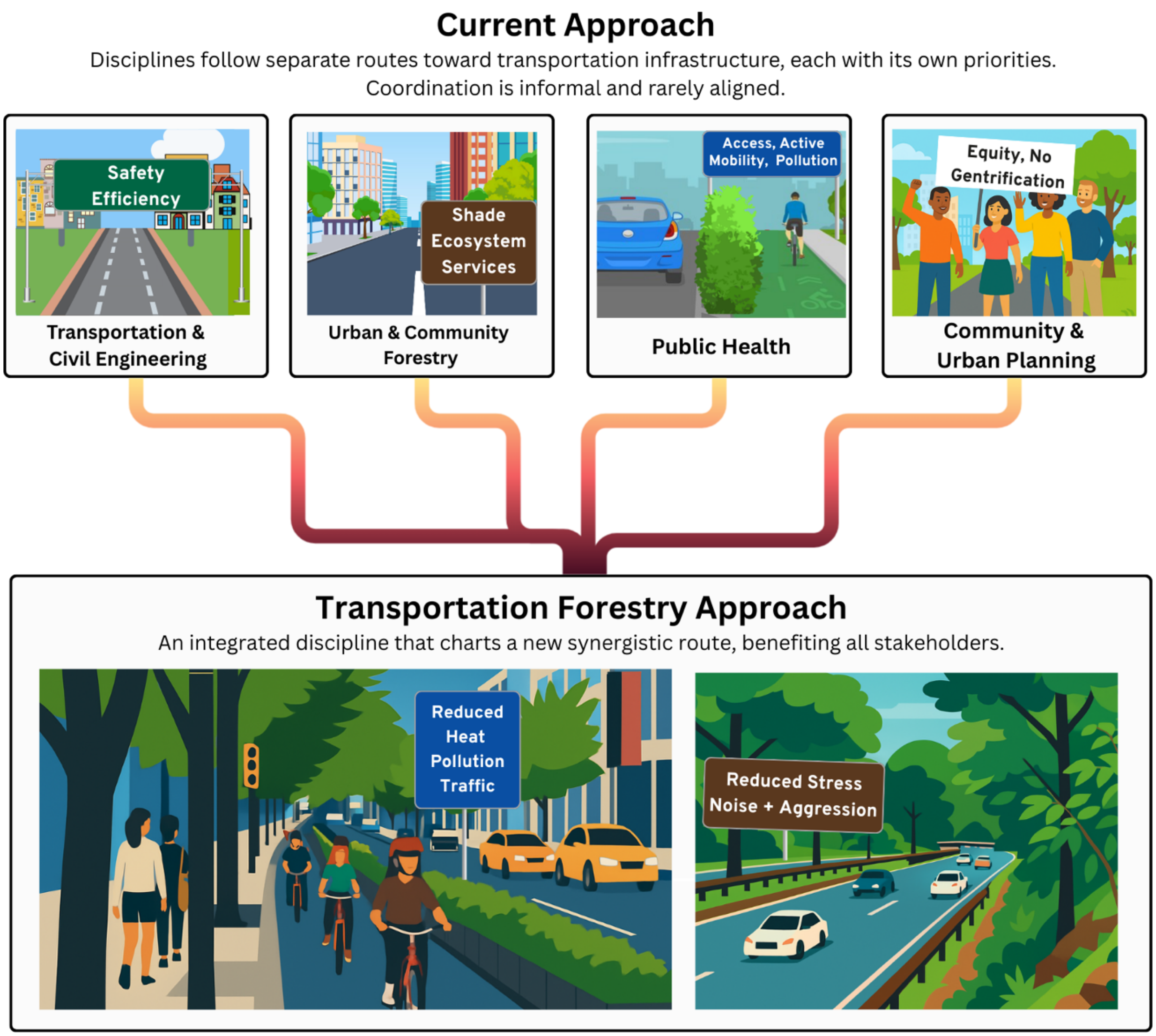

Figure 1. Transportation Forestry merges disciplines and approaches that currently work independently

Transportation Forestry's full potential cannot be achieved within existing silos. While strong evidence exists for the environmental, health, and social benefits of trees[8,12], most transportation agencies do not have the expertise or formal mandates to integrate U&CF and public health priorities into their designs. Yet careful Transportation Forestry approaches may yield these benefits while also reducing maintenance costs and improving safety. Core transportation manuals across the globe continue to emphasize tree avoidance or removal, offering little guidance on how to design transportation systems *with* trees rather than *around* them[14,15,28–30].

Without a dedicated subfield responsible for synthesizing and operationalizing this evidence, integration will remain inconsistent and minimal, likely dependent on individual champions, and unlikely to occur at scale.

A dedicated subfield is critical for context-dependent design. Transportation corridors vary widely in scale, function, and impact. Highways generating substantial pollution burdens may benefit from dense, strategically designed plantings that balance filtration, airflow, and safety. Local streets with lower traffic volumes may prioritize canopy, aesthetics, and social use to support shade, mental health, physical activity, and community cohesion. Optimizing these outcomes requires weighing trade-offs across safety, ecology, health, and equity. No single existing field is equipped to do at scale. Transportation Forestry would develop the tools, frameworks, and expertise needed to tailor tree-based interventions to specific contexts, optimizing the benefits and long-term viability of greenery along transportation corridors.

4. Benefits of Establishing Transportation Forestry

Roadway Safety. Safety is paramount to Transportation Forestry. Nearly 1.35 million people die annually in road crashes worldwide[31], among the top ten causes of death globally[32]. Millions more are seriously injured[33]. 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[34]. Roadside trees correlate with traffic-calming and reduced speeding[10] through visual friction reinforcing posted speeds[35]. Research also shows increased driver attention and shorter reaction times with roadside greening[36]. Trees spaced closer together influence vehicle position, moving drivers farther from road edges[37]. And U.S. crash data for urban settings indicate lower death and injury rates when trees are present[16], while the lack of vegetation can unintentionally increase speeds, exacerbate driver error, and reduce safety[35].

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[38]. Some trees reduce air quality through allergenic pollen and biogenic volatile organic compounds[23]. Furthermore, transportation is a substantial driver of climate change[39], as nearly 20% of all worldwide carbon dioxide emissions worldwide are sourced from the transportation sector[40]. Transportation Forestry requires design solutions maximizing pollution reduction while avoiding unintended consequences. Trees also effectively reduce roadway noise[41], but deliberate design and species selection is needed to observe the maximum benefits[42].

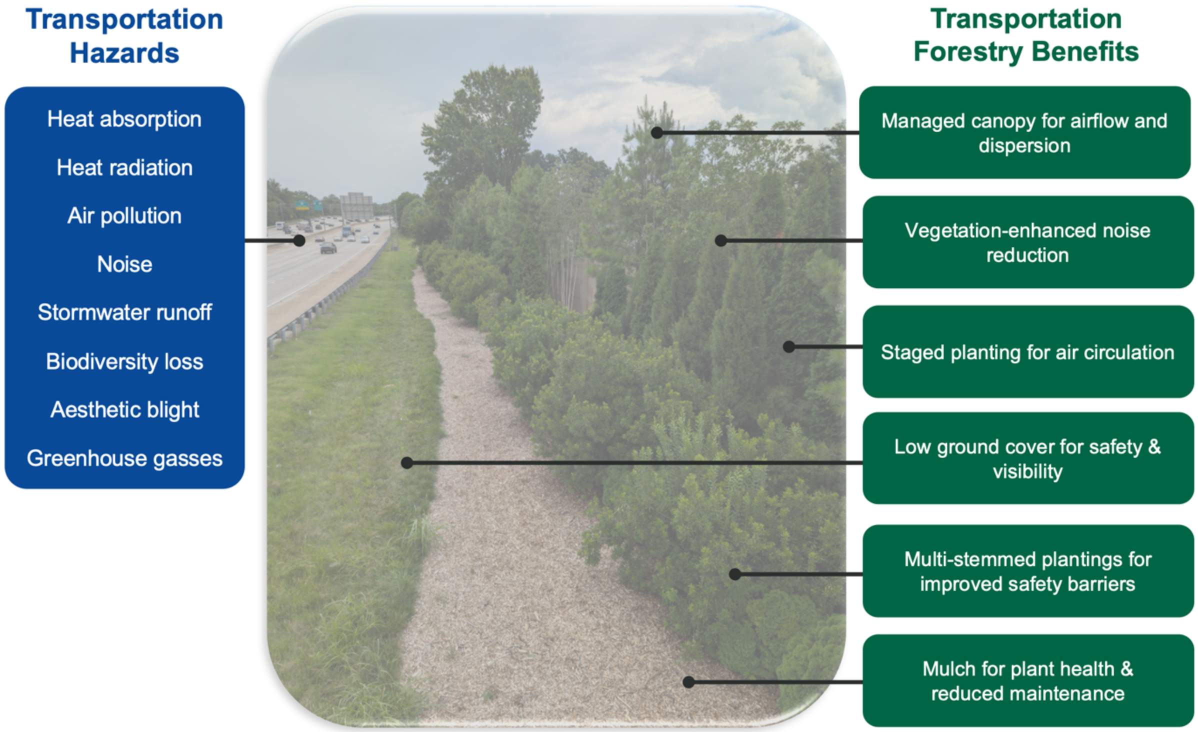

Figure 2. Green Heart Louisville is an example of Transportation Forestry along highways.

Health Promotion. Beyond mitigating transportation burdens, Transportation Forestry improves health in multiple ways. Green neighborhoods are associated 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[43].

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[44,45]. Resident engagement as stewards may also promote social cohesion, pride, and community attachment. 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[46]. Greened vacant lots near roadways are also associated with reduced crime and improved mental health[47].

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[48], which can improve merchant revenues through aesthetic and comfortable shopping environments[49]. 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[50]. 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[51], disproportionately affecting underserved communities[52]. Vegetation counters this through shading and evapotranspiration, mitigating climate-driven morbidity and mortality.

Equity. 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[53]. 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[54]. 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)[55].

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[56]. Encampment-related vegetation damage may increase maintenance costs, while nearby residents may object, weakening support for initiatives. Transportation Forestry must address homelessness seeking out refuge in roadside plantings to reduce vulnerable population exposures and enable successful implementation of Transportation Forestry initiatives.

5. Actions to Establish Transportation Forestry

We propose several actions to establish Transportation Forestry. 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 would greatly lower the implementation and maintenance costs compared to retrofitting. Furthermore, as expansion and alteration of facilities is a continuous process, there are ample and ongoing opportunities for the 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.

Policy and Planning. Transportation policy agencies maintain best practices and standards spanning from parcels to nations through complex, multi-volume documents[28,57,58]. 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.

Financing. Multi-sectoral financing strategies are needed to launch Transportation Forestry at scale. 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 leverage sufficient financing and widespread implementation.

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[59]. 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[60]. 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.

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 can 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:

Safety Mechanisms: Few articles consider road safety when evaluating the benefits of street trees[14]. Conversely, transportation industry research on crash circumstances (such as road geometries) and driver behavior (such as safe speed response) emphasize trees as fixed objects with serious safety risks, rarely acknowledging ecosystem services and community benefits. Rectifying and validating these perspectives across geographies and urban to rural contexts is critical. Current crash report data are primarily from federal sources and may not fully reflect the conditions faced by local governments[17]. Developing a “Safe System” approach can balance physical constraints with driver cognitive responses, such as attentiveness and posted speed compliance[61], while “crash taxonomies” can inform best practices for crash avoidance and countermeasures[62].

Vegetation-Driver Interactions: Aside from reduced access, little is known about roadside greenery in different contexts and its implications on driver behavior. Meanwhile, research on quantities and qualities of green infrastructure along roadways could inform efforts to balance climate, environment, active and vehicle transportation, and policy or utility constraints. Technologies like self-driving cars with RGB camera, 360-degree camera, depth sensor (like

LIDAR) and embodiment AI algorithms can generate real-time rich data of urban forests along transportation corridors, providing potential to establishing a scalable cost effective apporach to monitoring, analysis and issue detection. Tradeoffs between solar microgrid placement and tree planting spacing may increase as transportation and renewable infrastructure investments continue.

Tree Growth and Maintenance: The interaction of sub-surface root growth with paving can result in potential hazards and increased maintenance costs. Applied technologies may be used in forensic evaluations, such as using ground penetrating radar to evaluate root architecture and implement repairs before hazards become serious. As the practice of Transportation Forestry and related research grows, so will the knowledge about species selection to minimize damage to pavement and offset maintenance costs. In this context, the International Society of Arboriculture offers important guidance.

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[47], and limited generalizability. Transportation Forestry approaches should synthesize evidence across fields. Directed research holds promise for improving benefits and advancing nature-health research broadly.

Beyond Roads: The potential benefits of trees and vegetation in various transportation contexts remain largely underexplored. Rail lines, light rail systems and airports present opportunities to extend similar benefits and tradeoffs of greening. As with roads, trees along rail corridors could mitigate stress levels for passengers and conductors, akin to their documented restorative effects for pedestrians and drivers in urban environments. Greening around airports may improve traveler well-being by reducing stress and visual fatigue during transit or buffer against noise pollution during take-offs and landings. These scenarios may parallel the benefits observed along roads and streets, but research is needed to determine their translation and unique challenges to these contexts.

Governance and Collaboration: Advancing Transportation Forestry will require coordinated updates to best management practices, training programs, ordinances, and design standards. Input from multiple fields, particularly U&CF professionals and transportation agencies, will be necessary to develop guidance relevant across national and local contexts. Case studies and focus-group research on effective cross-disciplinary collaboration could identify best practices for communication and institutional integration. Lessons from the emergence of *road ecology*, which elevated fragmented knowledge into a cohesive multidisciplinary framework for ecological connectivity[63], could be particularly instructive. In China, early collaboration between transport planners, engineers, and landscape architects has enabled integrated roadside landscapes that extend beyond street trees to include linear parks, trails, and multifunctional buffers. Comparative research is needed to assess how such governance and professional models translate across cultural and regulatory contexts[64]. Evaluating existing policy and design tools for adaptive use: Context Sensitive Solutions and Complete Streets policies; NACTO design guidelines in the U.S.; "Woonerf" design in the Netherlands; "shared space" strategies in Belgium; Manual for Streets and Duty of Care in the U.K.; and the Urban Road Greenery Design Standards (No. CJJ/T75-2023) from the Ministry of Housing and Urban-Rural Development and Street Design Guidelines (No. T/UPSC 0013-2023) from The Chinese Society of Urban

Planning, or local landscape and climate specify guideline like Shanghai Street Design Guidelines in China[65].

Re-centering Transportation around Green Infrastructure: Most of our framing has been the ecologically sustainable and safe installation, maintenance, and care of trees and other types of green infrastructure where roads and streets are located. However, a paradigm shift would be to create new planning, ordinances, and transportaiont design systems that build transit and transportation cooridors around existing or desired, new, green infrastructure.

6. 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.

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