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 the deliberate integration of trees and vegetation into transportation infrastructure.

Introduction

Transportation systems play a critical role 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 air pollution and noise[5,6]. Combined with extensive parking, roads that prioritize cars foster a motor normative transportation system that minimizes active mobility, landscape connectivity, and community cohesion[7]. And car-dominated development and planning are not limited to select countries (i.e., the U.S.) but being exported to many other countries including the developing world[8,9].

We envision a radically different future: What if trees became a prominent component of transportation systems, offering efficient solutions to climate change, biodiversity loss, pollution, social isolation, and physical inactivity[10–14]? Despite decades of recognition that vegetation can mitigate transportation-related harms[15], progress remains limited. Current approaches are fragmented across disciplines; urban foresters often lack transportation expertise, traffic engineers rarely consider ecological functions, and public health professionals frequently work in parallel, rather than in lockstep, with these disciplines[1,16–19]. Such siloed approaches perpetuate suboptimal systems and adverse outcomes[20].

We propose Transportation Forestry as a new dedicated transdisciplinary subfield. Here, we define its scope, review its benefits, and outline actions to establish the subfield, including 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 communities worldwide.

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[21]. U&CF now drives urban green infrastructure development across cities, suburbs, and rural communities, managing trees and supporting infrastructure in public and private spaces[22]. Yet applying U&CF along transportation corridors requires distinct expertise[23]. Specialized knowledge is needed to address traffic management, root-pavement interactions, species suited to harsh conditions, air quality complexities, and visibility requirements[11,24–27]. Ecological understanding 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 strike a balance between these factors and safety considerations.

We define Transportation Forestry as the practice of deliberately integrating living vegetation with transportation infrastructure for societal and environmental benefits. This intentionally broad definition applies to a diverse range of facility types and contexts. Correspondingly, the definition applies to nearly any physical infrastructure that facilitates the movement of people and goods. Roads and streets are particularly relevant, comprising outsized portions of urban land and contributing substantially to environmental health burdens[28]. These span from highways to local streets and integrate with transit, parking, sidewalks, and bicycle infrastructure[29]. While the principles we propose here primarily address roadways and active transportation, they likely apply to other sectors, such as transit and railways, as well[12]. Transportation Forestry would also require a systems approach extending beyond trees. The green infrastructure leveraged by Transportation Forestry could span the rural-urban continuum[29], from landscapes in suburban areas to plant 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 the integration of 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, arboriculture, 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 and resilience. However, Transportation Forestry would also require expertise from utility arboriculture to guide pruning and rights-of-way safety; civil and transportation engineering to design safe geometries while minimizing sightline 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 and related negative impacts[30].

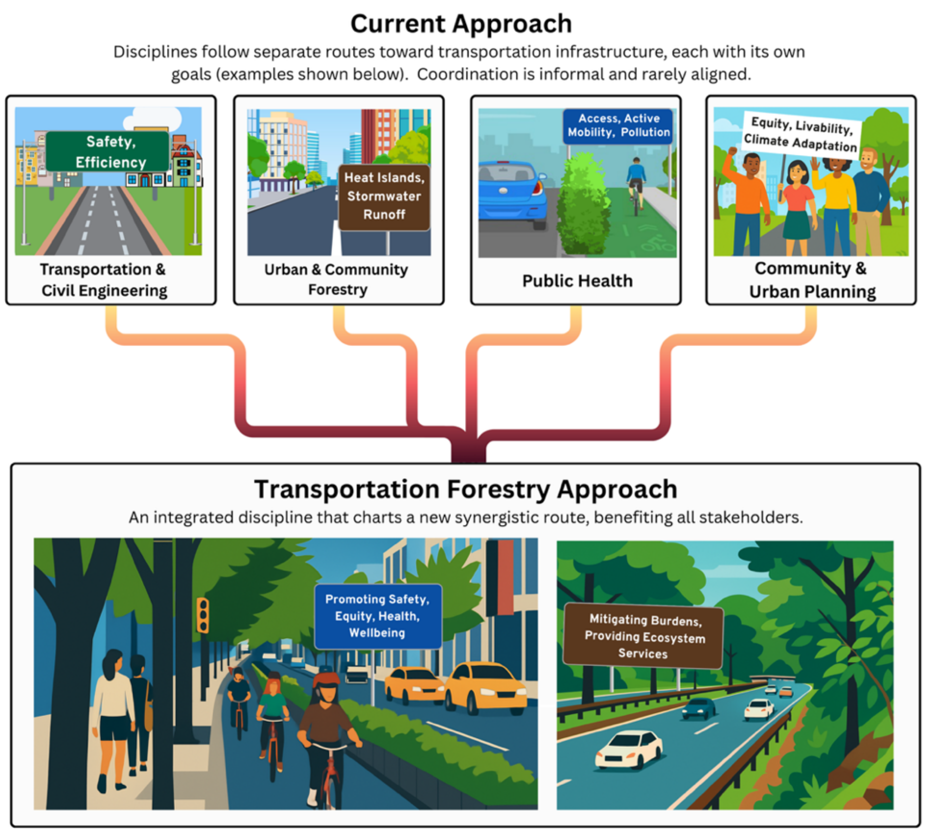

Figure 1. Transportation Forestry merges disciplines and approaches that currently work independently

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 (i.e., the Barcelona superblock model[31–34]) over the past several decades[16–18]. Instead, transportation systems are governed by entrenched hierarchies, processes, policies, and funding streams that are overwhelmingly centered within transportation agencies in many developed countries. Transportation infrastructure often commands substantially greater funding and regulatory authority than forestry and parks departments[35–37]. Until recently, multibillion-dollar freeway expansions faced little public scrutiny, while parks and urban forestry programs are frequently characterized as discretionary amenities rather than essential services[19,38]. This institutional power imbalance systematically marginalizes trees and green infrastructure in transportation planning decisions. 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[16–18].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's full potential cannot be achieved within existing silos. While substantial evidence exists for the environmental, health, and social benefits of trees[10,14], most transportation agencies lack the expertise or formal mandates to integrate U&CF and public health priorities into their designs. Disciplinary silos are also barriers for transportation-related initiatives in many cities, particularly among practitioners working to advance climate adaptation[19]. Careful Transportation Forestry approaches may yield wide ranging 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[16,17,39–41]. In tropical regions, road infrastructure is also a major risk of deforestation and ecological degradation requiring integration across disciplines beyond urban areas[42]. 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.

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 global branching of ecology into numerous subfields, including evolutionary ecology, landscape and spatial ecology, conservation ecology, and others[43]. Recent examples from scholars across the globe include ecological medicine[44], planetary health[45], and environmental neuroscience[46], each emerging from intersections from medicine, public health, environmental science, psychology, and/or related disciplines. Regarding the emergence of Transportation Forestry, many transportation systems across most countries were designed to address the safe and efficient movement of people and goods; today, they are also central to climate adaptation, public health equity, biodiversity conservation, and social wellbeing[1]. Urban contexts have evolved rapidly, but transportation policies and design frameworks have arguably not kept pace with these changes. As a result, trees and green infrastructure are often introduced late in the planning process, rather than core design elements[19,47]. The establishment of Transportation Forestry would create the specialized expertise and value statement to integrate trees into transportation systems from the outset, while also bringing new values and priorities into transportation agencies where these considerations have been largely overlooked. Ultimately, these shifts could help redress current institutional power imbalances by ensuring that ecological considerations carry more equal weight in infrastructure decision-making.

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 this 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.

Benefits of Establishing Transportation Forestry

Roadway Safety. Nearly 1.35 million people die annually in road crashes worldwide[48], among the top ten causes of death globally[49]. Millions more are seriously injured[50]. Vision Zero policies aim to eliminate traffic fatalities through systemic approaches that require policy review and innovation. Transportation engineering has historically emphasized clear zones free of fixed objects, including trees, on high-speed roads. However, research suggests that clear zone policies should reflect specific situations rather than being applied universally. While transportation leaders may recognize the benefits of vegetation, this understanding may not overcome perceived safety concerns in widely accepted design standards[17].

Trees can offer several safety-enhancing opportunities if properly designed. Impact speed is critical, as the fatality risk at 60 km/h is five times higher than at 30 km/h[51]. Roadside trees correlate with traffic-calming and reduced speeding[12] through visual friction, reinforcing posted speeds[52]. Research also shows increased driver attention and shorter reaction times with roadside greening[53]. Trees spaced closer together influence vehicle position, moving drivers farther from road edges[54]. U.S. crash data for urban settings indicate lower death and injury rates when trees are present[18,55], while the lack of vegetation can unintentionally increase speeds, exacerbate driver error, and reduce safety[52].

Transportation Burdens. Roadway traffic is a primary source of pollution 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[56]. Some trees reduce air quality through the release of allergenic pollen and biogenic volatile organic compounds[26]. Furthermore, transportation is a substantial driver of climate change[57], as 20 to 25% of all worldwide carbon dioxide emissions are sourced from the transportation sector[58,59]. Transportation Forestry would develop design solutions that maximize pollution reduction while avoiding unintended consequences. Trees can also effectively reduce roadway noise[60], but deliberate planting design and species selection are needed to observe the maximum benefits[47,61].

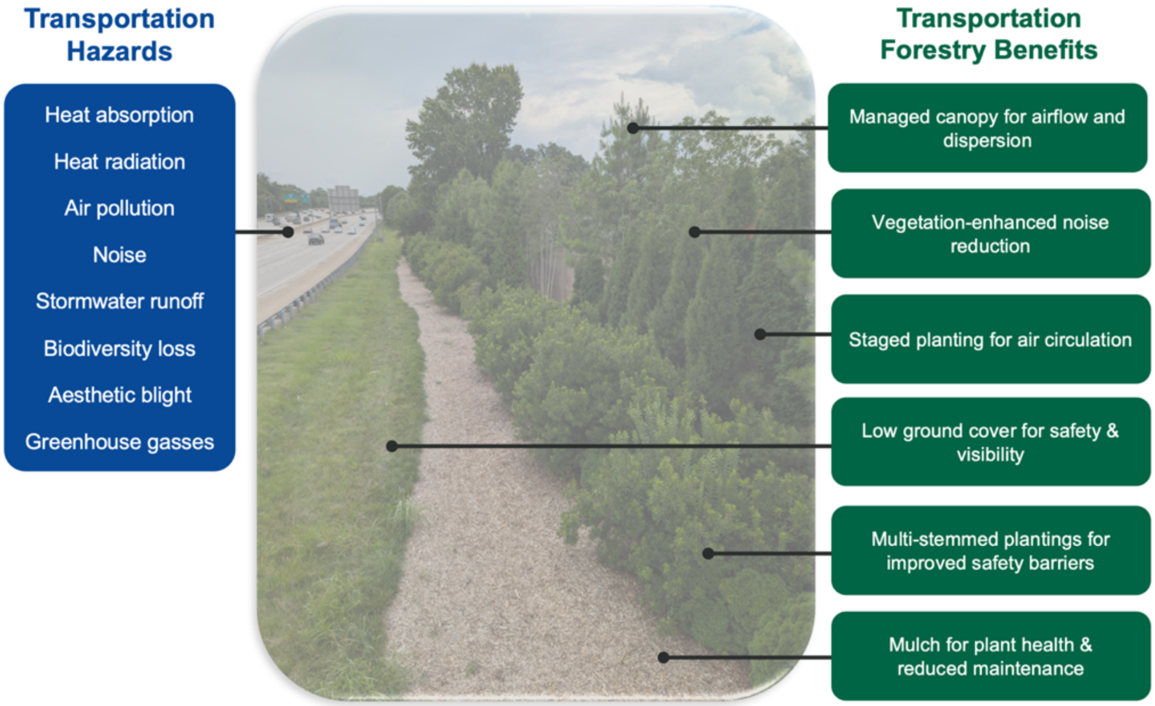

Figure 2. Green Heart Louisville is an example of Transportation Forestry suitable for a non-wildfire-prone area along a highway.

Health and Wellbeing. Beyond mitigating transportation burdens, Transportation Forestry would improve health in multiple ways. Green neighborhoods are associated with lower blood pressure and reduced incidence of cardiovascular disease worldwide[14]. High rates of tree canopy and vegetation cover also correlate with improved sleep, better birth outcomes, increased physical activity, and reduced chronic disease and mortality[14]. Vegetation along corridors facilitates social connections through aesthetics, cooling, and ecosystem services, increasingly recognized as crucial to wellbeing[62]. Transportation spaces significantly influence the public sphere, particularly physical activity, mental health, and social connection. Transportation-integrated green spaces are likely to improve social connection quality through enhanced cognitive function, reduced aggression, and improved affect[63,64]. 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 would facilitate 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[65]. Greened vacant lots near roadways are also associated with reduced crime and enhanced mental health[66].

Ecosystem Services. Given the outsized public presence of transportation facilities, the ecosystem service potential extends beyond health benefits and burden mitigation. Transportation-adjacent trees provide cultural services, including therapeutic landscapes near healthcare facilities, educational opportunities near schools, and aesthetic contributions that symbolize place[67], which can improve merchant revenues through aesthetically pleasing and comfortable shopping environments[68]. 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[69]. Transportation Forestry would presents opportunities to expand biodiversity by diversifying plant assemblages, prioritizing those that are native and adapted to survive in stressful roadside conditions, such as compacted soils, elevated temperatures, high salinity from de-icing, and air pollution[26]. More broadly, trees represent a potent nature-based climate solution. Impervious surfaces contribute to urban heat islands, and vegetation offers a uniquely practical and cost-effective solution for cooling. Urban heat is associated with the highest counts of climate-related disaster deaths[70], disproportionately affecting underserved communities[71]. Vegetation counters this through shading and evapotranspiration, mitigating climate-driven morbidity and mortality.

Equity. Transportation burdens are often inequitably distributed to disadvantaged communities, exacerbating preexisting inequities[72]. Transportation-related politics and policies have caused disadvantages across communities, from externalities associated with road placement to direct environmental harms, reinforcing longstanding divides[73]. Underserved communities near major corridors may benefit more from nature-based interventions. Residents who do not own cars and tend to earn lower incomes spend more time locally, suffer greater cumulative environmental burdens and have lower baseline health[74]. Many cities across Europe, North America, and other regions now adopt holistic greenspace equity goals, including the "3-30-300 rule" (three visible trees per dwelling, a 30% neighborhood canopy, and a green space within 300 meters)[75].

Another equity consideration involves unsheltered populations. Green spaces near transportation corridors, which are commonly accessible to this population, may encourage encampment occupancy and associated health implications due to air quality, noise, and heat exposure[76]. Support for Transportation Forestry initiatives from nearby (housed) residents may be weakened by concerns that proposed roadside plantings encourage encampments. Encampment-related vegetation damage may also increase maintenance costs. Transportation Forestry must, therefore, address homelessness, collaborating to reduce vulnerable populations, particularly those seeking refuge in roadside plantings, to enable the successful implementation of Transportation Forestry initiatives.

Actions to Establish Transportation Forestry

We propose several actions to establish Transportation Forestry. We call for comprehensive policies that reflect the best available evidence and integrate arboriculture, horticulture, and landscape architecture with traditional transportation policies. Proactive integration of greening into new transportation projects would significantly 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, departments of transportation, public health, and planning, and the 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[39,77,78]. These systems require significant capital investments, making policy and economic investment in roadside trees more time-sensitive. Rapidly expanding science about urban trees has not adequately intersected with transportation guidance. Roadside vegetation receives modest attention, often perceived as an aesthetic backdrop or a safety hazard[17]. Recent multidimensional research indicates that mobility system policies should integrate trees to achieve sustainability goals[16]. Natural elements must be incorporated into project planning from the earliest stages, with resident buy-in (i.e., via facilitated local, non-governmental organizations) as well as dedicated, sufficient budgets for projects to ensure they are not only integrated within the gray infrastructure but also highly functioning and adequately maintained. Concurrently, community programs like Adopt-a-Highway may play supportive roles and offer strong returns on investment[79]. Focused initially on litter reduction and civic pride, such initiatives could increasingly emphasize public health promotion and biodiversity to align with the broader goals of Transportation Forestry.

Financing. Multi-sectoral financing strategies will be necessary to scale up Transportation Forestry. Despite documented benefits and extensive net savings across sectors, many transportation agencies are unlikely to initially prioritize Transportation Forestry as mission-critical or cost-effective, given prevailing narratives that frame green infastructure as discretionary amenities rather than essential infrastructure[38]. This perception problem is both reinforced by and contributes to a systemic funding imbalance: urban forestry and park agencies routinely pursue transportation grants (i.e., for fund trail systems and greenways[80]), yet transportation agencies rarely seek parks or forestry funding to support roadway projects. This one-directional flow of resources reflects not only the broader prioritization of mobility infrastructure over green infrastructure, but also the disproportionate funding and regulatory authority commanded by transportation departments relative to forestry, parks, and recreation agencies. To overcome these barriers, comprehensive economic analyses and health impact assessments[81,82] among other economic valuation approaches[83] are needed that quantify the cost savings and co-benefits of Transportation Forestry across health, housing, disaster resilience, environmental quality, and related sectors. Such evidence can help reframe trees as essential infrastructure investments and leverage the multi-sectoral financing necessary for 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 the highest degree of transportation harms and greatest potential benefits. Areas with the lowest socioeconomic status tend to have the lowest tree canopy coverage[84]. Greening initiatives in disadvantaged communities often face low adoption, maintenance, and survival rates, which are further 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[85]. 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 also call for the development of interdisciplinary professional education and workforce programs that promote broader communication and knowledge transfer. Leadership is necessary to develop this transdisciplinary expertise, fostering trust and conversations between disciplines and agencies that currently have little overlap. Integrated curricula could span undergraduate and graduate levels, featuring cross-listed courses and a Transportation Forestry minor that includes classes from relevant disciplines, as well as a capstone project. Coordinated materials and case studies will be necessary to address disciplinary-specific challenges, and experts from relevant disciplines must collaborate in the development of training and educational materials. Certificates could serve distance learners and professionals seeking continuing education. These could be offered by such professional organizations as the Transportation Research Board, the National Association of City Transportation Officials, the American Society of Landscape Architects, and the Urban and Community Forestry Society. Such organizations could also pursue accreditation standards.

Research Needs. Finally, we call for increased research to develop evidence-based best practices in Transportation Forestry, which could also help inform materials for workforce development in this space. While U&CF research continues to grow steadily, specific research on trees and transportation remains limited. Essential topics include:

Safety Mechanisms: Few articles consider road safety when evaluating the benefits of street trees. Conversely, transportation industry research on crash circumstances (such as road geometries) and driver behavior (such as safe speed response) emphasizes 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 national sources and may not fully reflect the conditions faced by local governments. Developing a "Safe System" approach could balance physical constraints with driver cognitive responses, such as attentiveness and posted speed compliance, while crash typologies can inform best practices for crash avoidance and countermeasures.

Vegetation-Driver Interactions: Relatively little is known about roadside greenery in different contexts and its implications on driver behavior. Additional research on the quantities and qualities of green infrastructure along roadways could inform efforts to balance climate, environmental, active, and vehicle transportation, as well as policy or utility constraints. Technologies like self-driving cars with RGB cameras, 360-degree cameras, depth sensors (such as LIDAR), and embodiment AI algorithms can generate real-time, rich data of urban forests along transportation corridors, providing potential for establishing scalable, effective approaches to monitoring, analysis, and issue detection. Additionally, prior work has shown that urban trees and roadside vegetation can directly affect autonomous vehicle operations by occluding traffic control devices and reducing line-of-sight visibility[86], interfering with LiDAR- and GNSS-based localization accuracy[87], and creating late-detected hazards in real-world autonomous driving deployments, particularly due to low-hanging canopies and roadside vegetation[87]. More research is needed to address these challenges by developing improved perception, localization, and infrastructure assessment methods that enable the safe integration of vegetation and urban trees into autonomous-vehicle-ready transportation environments. This is crucial, given the potentially massive reductions in crash rates that could result from switching from human-driven to autonomous vehicles[89,90].

Tree Growth and Maintenance: The interaction between subsurface root growth and paving can result in potential hazards and increased maintenance costs. Applied technologies can be utilized in forensic evaluations, such as using ground-penetrating radar to assess root architecture and implement repairs before hazards become severe. 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 Best Management Practices for trees, construction, and root management from the International Society of Arboriculture provide important guidance[91]. Tradeoffs between solar microgrid placement and tree planting spacing may also increase as investments in transportation and renewable infrastructure continue.

Public Health Benefits: Despite the growing literature on the health benefits of greenspace and other natural landscapes[92,93], most studies cannot inform practice due to vague definitions and measures of nature[94,95], inadequate results from experimental and implementation research[66], 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 help mitigate stress levels for passengers and conductors, similar to their documented restorative effects on pedestrians and drivers in urban environments. Greening around airports may improve traveler wellbeing 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 in these contexts.

Governance and Collaboration: Advancing Transportation Forestry will require coordinated updates to best management practices, training programs, ordinances, and design standards to ensure effective implementation. 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[96], could be particularly instructive. In China, early collaboration among transport planners, engineers, and landscape architects has enabled the development of 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[97]. 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[98].

6. Conclusion

Establishing Transportation Forestry offers a novel approach to 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. Paradigm shifts would create new planning, ordinances, and transportation design systems that build transit and transportation corridors around existing or desired, new, green infrastructure. Developing necessary collaborations, tools, and workforces will result in healthier, more livable urban communities worldwide.

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