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Rethinking "Streetline Forestscapes" in a Broader Context of Urban Forestry: In-Between Ecological Services and Landscape Design, with Some Evidence from Rome, Italy

Matteo Clemente

Department for Innovation in Biological, Agro-Food and Forest Systems (DIBAF), University of Tuscia, Via S. Camillo de Lellis, I-01100 Viterbo, Italy

Abstract: Urban forestry development plans, which sometimes pass under the "slogan" of urban forestry, are a great opportunity for our cities. Improving urban forestscapes is a successful part of any urban sustainability strategy, including concrete actions in support of citizens' well-being. The experience of Italy with the most recent forest planning legislation and a specific focus on Rome, with the recent implementation of a local forest plan, is thus fundamental to give due weight to the different roles of road trees in the ecological, architectural, engineering and social fields, differentially considering some aspects relevant to urban forestation plans and in particular in projects for the new planting of road trees. The present study discusses the main issue of road trees as a part of the green system, linking the "porosity" of urban landscapes with beneficial contributions in terms of ecosystem services. It is outlined how considering the issue of road trees within the more general question of the structure of urban and metropolitan green areas, which includes urban parks, ecological corridors between wilderness areas, residual green areas of buildings, riparian strips of rivers, agricultural areas, natural and wooded areas, is necessary in current planning for urban forests. The project of new plantings and replacement of existing trees should also follow a careful analysis of the local and regional ecological network, promoting a full integration with the mobility network, the service system and the city's public spaces, including vacant land. Any strategy promoted by urban forestry, and in particular tree-lined roads, should work in synergy with the other measures for urban redevelopment and landscape enhancement of the city in a truly holistic perspective. Finally, the identity of street tree lines in building the image of a given city should be significantly enhanced, recovering in some ways (and giving value to) the aesthetic and scenic role of urban trees.

Keywords: urban forestry; street design; ecological network; landscape planning; Rome

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1. Introduction

Urban forestry has become a crucial policy issue in recent years, attracting an increased attention of the international scientific debate aimed at informing (central and local) government policies to promote sustainable development and the fight against climate change [1–3]. Metropolitan councils have recently started implementing strategic programs to increase the tree heritage and to promote actions favoring urban green and more livable streets with natural and aesthetic elements [4–6]. Among advanced economies, there is a favorable convergence of initiatives and programs in European countries, which have made significant investments to promote urban forestry interventions [7–9]. Tree planting and city reforestation have several objectives, such as the mitigation of atmospheric pollution (CO_2 sequestration, pollutants containment), the reduction in the unwanted effect of the urban heat island, the intrinsic protection of biodiversity, as well as an indirect reduction in noise pollution and the improvement of the drainage system in metropolitan areas [10–12].

Generally speaking, the trees bring shade, making small parking areas comfortable and contributing to the quality of the urban space [13–15]. In a more structured perspective, urban forestry interventions can be considered a "natural based solution" to urbanization, and can be framed, especially when it comes to trees along road axes, in the topic of green infrastructures, which participate in the ecological network of the city, favoring the pedestrian dimension of the route and the scenic beauty of the metropolitan arena [16–18]. Scientific literature and strategic urban forestry programs have mainly concerned the functional dimension of urban trees, both in ecological–environmental terms, and in a purely agronomic–forestry dimension [19–22]. The planting of new trees in our cities can have a great impact in ecological and environmental [23], especially if they are carried out in the capillary network of urban roads [24], where heat islands and the uncontrolled runoff of rainwater may create extreme damages to settlements [25–27].

By contrast, the dimension of urban design—despite being crucial to any analysis of land suitability—seems to be less investigated; however, the perceptual relationship of road trees with respect to urban morphology and, in particular, the human scale of the sidewalk where the pedestrian walks, with all the implications in terms of urban furniture, width of passages, and relationship with the fronts of buildings make the issue of landscape design a particularly appropriate perspective of study when planning urban trees in a truly sustainable perspective of metropolitan greening [28–30]. A traditional landscape perspective, aimed at relating tree species with the identity of the places, appears neglected in the guidelines and in the preparation of strategic programs promoting urban forestry [31–33]. The project of planting and replacing the tree-lined roads, with all its criticalities, brings within itself the great opportunity of being able to address a redesign of urban sidewalks, with a real impact on the quality of the public space [34–36].

In this direction, the strategic plan of urban forestry of the National Plan of Recovery and Resilience (the so called PNRR) in Italy, likely one of the more advanced programs on sustainability ever developed in a Mediterranean country and fully in line with the European Green Deal directives, underlines the issue of the heterogeneity of the new planting species, recommending to put "the right tree in the right place", in line "with the bio-geographical and ecological characteristics of the places" [37–39]. It is left to strategic and operational plans to define "where" and "how" the different cities will have to face the problem of the choice of tree species and in which urban areas or roads to intervene [40–42].

Following a description of the relevant functions of urban trees, our study focuses on current strategic programs promoting urban forestry—with a careful analysis of a paradigmatic case study—emphasizing the importance of creating stronger synergies among all policies addressing sustainability in urban development [43,44]. We assume that a better interaction between policies focusing on the ecological significance of landscape and landscape design would also help to improve the impact of urban trees [45–47]. As a result, all positive functions that road trees can provide must be considered as part of the overall green system, as a potential way to address the porosity of urban landscapes, giving further value to the importance of urban trees in constructing and protecting a place's unique features [29,41,48].

In this line of thinking, assuming that the guidelines of the Italian Strategy of Urban Forestry can be, in some ways, generalized to a broader socioeconomic context, our paper aims at investigating the issue of streetline forest landscapes, with particular reference to the planting and/or replacement of new trees on road pavements [45,49–51], also in consideration of the strategic programs implemented by various Italian cities. While being valuable for researching the issue of streetline forest landscapes, particularly the planting and/or replacement of new trees on road pavements, the design of this study is eminently simplified and based on a literature review at a broad spatial scale, a focus on Italy as the normative framework, and a more in-depth analysis of a case study in Rome, the capital city of Italy, considered a paradigmatic example of multifaceted, complex and not completely managed dynamics inherent in urban forest planning and design at the city level,

especially in socioeconomic contexts with permissive spatial planning and a past experience in urban informality and planning de-regulation.

The structure of this study, as reflected in the structure of this article, is therefore reflecting a storytelling approach. Following a description of the relevant functions of urban trees, this article focuses on current strategic programs promoting urban forestry in Europe, emphasizing the importance of creating stronger synergies among all policies addressing sustainability in urban development. A better interaction between policies focusing on the ecological significance of landscape and landscape design would also help to improve the impact of urban trees, and is considered a key issue for European policies, being in turn exemplificative of possible strategic lacks in spatial planning at the country scale, as the example of Italy can outline.

As a result, all the positive functions that road trees can provide must be considered as part of the overall green system, as a potential way to address the porosity of urban landscapes. Assuming as well that the selection of tree species is critical—basically according with the empirical evidence stemming from the case study—this discussion addresses the issue of urban forestry in a critical way, beyond the consideration that a large number of new trees can still be a positive solution for the environment and beyond the "fascination for urban greenery" [52,53]. This paper concludes by providing some hints for future studies, suggesting to concentrate on specific and practical issues, such as relating the strategic plan of road trees, with the design of the sidewalks with urban supplies on a local scale [13,28]. In this perspective, to systematize the road forestation plan with any Green Plan, which includes urban parks and protected areas, seems to be an appropriate take-home message from this research experience.

As a matter of fact, the systemic approach of the Italian Strategic Plan incorporated in the PNRR may provide a reasonable vision adaptable to broader contexts [37,54], suggesting an integrated planning of road trees, sustainable mobility, and public services. The storytelling of an Italian experience, and the focus of the strengths and weaknesses of urban forest planning in Rome, the capital city of Italy, may thus contribute to avoid planning mistakes at broader spatial scales, and especially in the same socioeconomic contexts, concentrating in turn on biodiversity issues (species selection), preservation of historical/landscape amenities, and safety in the design of street tree lines, as the specific contribution to an integrated "city forest" strategy. This article concludes that any strategy of urban forestry cannot demise the eminent contribution of tree streetlines to ecosystem functions and services in European cities. Despite being largely grounded on a Mediterranean context, apparent and latent hints of the study seem to be appropriate and pertinent to other contexts, from Western to Northern Europe, from Central to Eastern Europe, where big cities have important stocks of street tree lines to manage and preserve from degradation [55,56]. Based on these premises, the issue of managing street tree lines in a broader "urban forestry" perspective appears to be a key argument for present and future science and for policies of mitigation and adaptation of climate warming, in the context of global change and worldwide urbanization involving both advanced economies and emerging countries [57–59].

2. The Role of Urban Trees and the Specific Focus on Streetline Trees: A Short Review

Streetline forestscapes play multi-functions in urban forest ecosystems. Aesthetic and shading values, security to motor vehicles, pedestrians, and roads, and coping with climate change are basic services for streetline forestscapes. Other ecosystem services such as noise reduction, diffusion, and deposition of local genetic pollutants, such as particles, vehicle exhausts, allergenic pollen, and flying catkins, have been taken into consideration in recent years. Therefore, to balance ecosystem services in different street sites in urban, suburban, and peri-urban areas according to their key functions is very important to design, establish, replace, and improve the quality of streetline forestscapes or street trees in the future. The main functions provided by trees in metropolitan environments can be summarized as follows:

(i) Ecological–environmental functions, which includes the reconnection of the ecological network through green corridors, biodiversity conservation, regulation of microclimates, and mitigation of the heat island, mitigation of atmospheric, soil, and water pollution, regulation of rainwater outflows, as well as noise mitigation [60,61].
(ii) Social–recreational functions. Whether we consider urban green areas, or whether they are linear parks or green infrastructures with trees connected to the linear network of cycle and pedestrian mobility, the presence of vegetation plays an essential role in the conformation of public spaces for sociality and to enjoy free time outdoors [62–64].
(iii) Psycho–physical health and well-being functions. The presence of trees and vegetation—even in a simplified, tree-line shape—in an urban environment favors the psychophysical well-being of citizens and has beneficial effects on health conditions in general [65].
(iv) Landscape–architectural functions. Trees and vegetation are finally essential for building a high-quality urban landscape from the aesthetic/scenic point of view, participating in the design of public spaces through wings, backdrops, perceptual alignments, and masking of facades [66]. The trees are also essential for shaded resting areas, squares, and spaces for public use, corroborating the urban project, together with the flooring, the street furniture, and the lighting [30].

2.1. The Environmental Role of Urban Trees

The planting of trees and the increase in vegetation in urban contexts—and especially the densification of tree lines—have become thematic strategies for the European policies, which in recent years have activated various programs on the topic of green infrastructures and nature-based solutions [67,68]. The basic model taken as a reference for the development of ecological networks is the one attributable to the ACB technical scheme (Core Areas–Corridors–Buffers), which indicates a system of central natural areas ("Core Areas"), connected by a set of corridors ("Corridors"), intended mainly as lines of movement of the fauna, and surrounded by buffer areas ("Buffers") against external pressures [69]. The tree-lined streets, in this network on a territorial scale, can play an essential role of reconnection within the ecological network, penetrating in a capillary way within the urban fabric [70,71]. In this perspective, the trees in the streets represent a continuous linear system, similar to ecological corridors, for the ecosystem services they can provide, starting from those of regulation (mitigation of the microclimate, air quality, noise mitigation, regulation of outflows), to those related more properly to the maintenance of biodiversity of plant and animal ecosystems [54,72,73].

Urban trees, together with urban green areas, as demonstrated by recent experiments, perform a temperature control function for urban microclimate, by providing a contribution to counter the effect of Urban Heat Islands [25,74]especially in denser areas with compact settlements, where the only green component is represented by street tree lines and small green courtyards with few trees. The problem is particularly acute in this historical moment in which the perception of climate change has made us aware of the damages caused by urbanization [75–77]. It is a phenomenon that is caused primarily by radiation and thermal characteristics of the materials that make up the urban surfaces (e.g., asphalt and cement), where the absorption of solar radiation prevails on the reflection; but also by the activities carried out in urban areas from industrial activity and traffic to heating and cooling systems [78,79]. Vegetation plays an essential ecosystem service also for the air quality, contributing to carbon storage [80,81]. In reference to this, urban trees can play a fundamental role for storing the carbon dioxide present in the atmosphere, purifying the air and mitigating the damages induced by the consumption of soil and the emission of greenhouse gases [82].

Moreover, vegetation plays an important mitigation role overall, both for air pollution and noise pollution, which is considered one of the environmental stressors, together with urban overcrowding and traffic, with respect to which the trees with their foliage

could have a passive shielding function against the propagation of sound waves [23]. The environmental–ecological function of street tree lines naturally includes the theme of biodiversity, as it is the basis of the existence of living organisms and of the survival of the species, which is increasingly threatened by human pressure on the territory and which has become a priority for EU policies [67,83,84].

2.2. The Social Dimension of Urban Trees

Urban forestry, and more in general, the presence of vegetation and other natural elements in the urban space, mainly in a street tree-line shape, still play an important role in the creation of public space. The presence of resting places to sit, to meet people, to play and to do other outdoor activities, underpinned by the presence of vegetation, make them more attractive places [85]. As in a virtuous circle, it is the continuous presence of people that ensures a greater security for those places, promoting social inclusion and participation processes, which ultimately could improve cohesion and sense of community [63,86,87]. It should be noted that the public space today is much more represented by the urban parks and by "linear parks", hybrids pedestrian routes (a cross between street and park), rather than "squares" in their well-defined configuration in the urban fabric, as places where people meet each other, according to the historical tradition of our cities [28]. Streets today represent an essential dimension for public life, being crossing places for pedestrians, but also resting places, equipped with elements of street furniture, benches, activated by the presence of services, bars, and activities open to the public on the ground floor of the buildings, made attractive by shop windows. The social dimension of public space brings back the issue on the accessibility and the use of the places as well as on the urban project, which aims to promote human activities outdoors, which are among the major factors that determine urban vitality [62,85]. Streetline trees, together with urban parks, can also play a playful–recreational function, an aesthetic and architectural function, as well as a cultural or educational one, and they may also contribute to raise environmental awareness. Just think about the educational values and the social benefits of taking care of the public green and of urban gardening, which often includes activities conducted with citizens and school children to plant trees.

2.3. Well-being and Human Health: The Contribution of Urban Greening

Another important issue related to the presence of trees, vegetation, and natural elements into the urban context is that of human health and well-being. The presence of parks and street tree lines positively affects the physical and psychological health of the residents and improves the quality of life [88]. As mentioned above, greenery has the function of mitigating environmental stressors caused by the intensification of a heat island, pollution, overcrowding, and noise from traffic by creating calm spaces, where even the elderly, children, and disadvantaged categories of users can find a comfortable environment [61,89]. Several studies show that green areas, including street tree lines, can have a positive influence on psychological well-being, on the mood and even on the mental balance of the users, without forgetting about the contribution to the aesthetic quality of the urban environment, which favors the creation of a healthy social ecosystem [37,54].

Studies regarding the relationship between green spaces, health, and social well-being highlighted the cause–effect relationship between greening and health in a better and more defined way than other studies ever did before. The systematic attendance in the daily life of parks and green areas is taken as essential, like a vitamin intake in human nutrition. The presence of parks and streetline forests for recreational purposes promotes the use of them along with outdoor sports activities by the residents, with a positive effect on health. Data from the World Health Organization (WHO) on the social costs associated with a sedentary lifestyle and lack of physical activity are also alarming. This is a true medical emergency, since sedentary behavior (along with an inappropriate diet, smoking, and alcohol) are the leading causes of chronic diseases, responsible for 80% of mortality in Europe (obesity, cardiovascular disease, diabetes, tumors, and others).

The literature puts street tree lines in a close relationship with human activities that can be carried out within them, emphasizing how the urban form, the presence of equipped pedestrian paths, bike paths, parks, and surrounding green areas promote pedestrian mobility and physical activity in the open space, with direct benefits on people's health [75,90]. Beyond the considerations about medical health issues that can be explored in other scientific contexts, the theme of urban green spaces becomes a critical issue for urban planning and the urban regeneration project [91,92]. The issue that concerns more closely our discussion, based on human and environmental well-being, is that of the design quality of green areas, in terms of biodiversity protection and optimization of ecosystem services in urban areas [93]. The project of street tree lines should consider, to that effect, the exclusive use of native species, as well as technical issues such as phyto-sanitary-type preventive measures, the use of essences that optimize the mitigation of air pollution, strategies for improving urban bioclimatic conditions, and the mitigation of heat islands [94]. Furthermore, landscape design should take into account a series of factors associated with human activities that take place in open spaces, including street tree lines, which give a social dimension to the public space [16,36].

2.4. Landscape Design and Street Trees: The Aesthetic, Scenic, and Ornamental Perspective

The ornamental and aesthetic function of the trees inside the city, little mentioned in the scientific literature of recent years—in favor of their ecological functions—was well recognized in the 19th and 20th century culture, which marked the wide boulevards with ordered rows of trees. The tree-lined streets create perceptive alignments, mark the rhythm of the street, create intriguing maskings of the building facades and, generally speaking, make the public space more pleasant. In Europe, the ornamental function of trees was particularly important in the design of the nineteenth-century city [45,95]. Large trees, especially broad-leaved trees, lined the wider streets, creating an aesthetically valid microcosm in summer and, with the loss of leaves, a minimum impedance to the luminous flux in winter. The urban design has greatly benefited from the shape and colors of the different tree species, playing with the posture of the standing plants, with the overall biomass (e.g., height and trunk diameter), as well as with the structure of the leafy boxes [96]. In the last century, the importance of urban beautification has reduced considerably, in the face of a settlement expansion toward the peripheral areas, where the intervention of design and the demand for aesthetics have progressively reduced. On the contrary, it is increasingly necessary to reconnect the urban design for the aesthetics of public street space with the ecological benefits of tree-lined streets [46]. Reconnecting architectural, ecological, and forestry approaches makes it possible design tree-lined streets that simultaneously meet different needs of the city, including ecological services and the quality of public space, making cities more livable and, at the same time, more sustainable.

3. Methodology

The present manuscript includes a sort of "storytelling" based on a literature review and synthesis from references, elaboration/re-elaboration of written and unpublished personal views, and a broader analysis of a case study based on both qualitative approaches (photographs, maps, physical description of places, and evocative landscapes) and some official statistical data delineating the background context. The storytelling suggests how the actual planning system for urban forestry in Italy should be better analyzed (and possibly improved) to address such issue, representing an example of research and policy action for other Mediterranean countries, traditionally less aware of the issue of urban forestry compared with Northern countries [97]. At the same time, this study incorporates a concise review and analysis of national and regional planning instruments emphasizing the importance of urban trees in constructing and protecting a place's unique features, as the case study selected may document. Selected for its problematic approach to urban forestry, and the large stock of street tree lines still present in the territory, the case study of Rome, likely better than other cases in Italy, such as Milan city—with a broader

experience in urban forest planning, but a less extensive stock of tree lines in the urban landscape—namely surface, shape, and biodiversity, makes it possible to delineate the strengths and weaknesses of the actual planning.

While not completely relevant in the study area, the connotation between street tree and road tree is different, and the range of road tree, which comprises streets in urban and roads outside of urban areas, is broader than that of street tree. Trying to give a precise boundary to our study, we intend to focus on street tree lines, defined as trees along urban (consolidated) streets, basically associated with compact-dense or semi-dense settlements, excluding trees associated with exurban high-ways, railways, or riverways. According with the definition of "urban greenspaces", the latter issue is important when the width of street trees covers more than one row, essentially two or more, creating a sort of green pathway, and also when greenspaces derived from street trees' canopy border neighboring green spaces, namely urban gardens, green allotments, cemeteries, or small parks. We used maps and photographs in the case study in order to better delineate our main focus using visualization and localization for the readers' complete documentation and reproducibility of our approach.

3.1. The Italian Strategy of Urban Greening and the Lack of a Specific "Streetline" Trees Planning

In Italy, a Mediterranean country with a traditional experience in ornamental tree lines, especially in largest cities, a "National Strategy of Urban Green. Resilient and heterogeneous urban forests for the health and well-being of citizens", drawn up in 2018 and implementing the Law number 10/2013 ("Rules for the development of urban green spaces"), collects a series of technical contributions and defines basic criteria to guide urban and peri-urban forestation in the country. The new vision of urban greening places the following strategic objectives at the center of field actions: (i) protection of biodiversity and ecosystem services, (ii) resilience to climate change, and (iii) improvement of citizens' well-being and quality of life. The strategy provides the implementation of plans and projects based on ecosystem services and on the network of green infrastructures (including natural based-solutions). With this framework in mind, the National Recovery and Resilience Plan (PNRR) has more recently provided large-scale actions of "protection and enhancement of urban and extra-urban green" in metropolitan cities, planting 6.6 million trees for 6600 hectares of urban forests, thanks to a budget of EUR 330 million [37,38].

In 2021, the "Urban and extra-urban forestry plan" was approved with the aim of providing a common methodology based on solid scientific references in order to identify and plant the right tree in the right place (i.e., tree consistent with the biogeographical and ecological characteristics of the places) [39]. The plan was grafted onto some national experimental funding programs for urban forestry and green infrastructures. The Climate Decree and the experimental urban forestry program (former Ministry of the Environment for the Protection of the Territory and the Sea (MATTM)), provided the financing for an experimental program for planting trees, replanting, and forestry, as well as for the creation of urban and peri-urban forests in metropolitan cities, allocating resources for a total of EUR 33 million for the years 2020 and 2021. In April 2021, the Ministry of Ecological Transition launched, in collaboration with the national association of municipalities (ANCI) and with the scientific contribution of the Italian High Institute of Environmental Protection and Research (ISPRA), the first experimental program of interventions for adaptation to climate change in urban environments (experimental program for adaptation to climate change in urban area). This program was also aimed at implementing green and blue interventions, assumed to cover at least 50% of the requested loan. The program, aimed at 103 Italian municipalities with a population equal to or greater than 60,000 inhabitants, provided a distribution of resources according to quantitative criteria based on resident population and municipal area, for a total of about EUR 80 million.

The 82 Italian municipalities adhering to the call presented experimental projects aimed at facing the risks caused by climate change, starting from the events that have

already occurred in the past and the consequences documented on the territory, also deploying here a good planning in terms of green and blue interventions (i.e., creation of green areas, redevelopment of public parks, peri-urban woods, green roofs and walls, cisterns for collecting and reusing rainwater). Being aimed at the urban environment, this program has mainly involved the more urbanized areas of the cities with more precise interventions located in specific places of living (waterfront, squares, municipal villas, schools, ex-freight yards, slopes cycle paths). The National Forest Strategy, in turn granted municipalities with a contribution of 75% of the costs incurred for the planting of forest species for the reduction in the main air pollutants present in urban areas.

Moving to the local level, for instance, Milan launched the FORESTAMI project (started from a research project of the Politecnico di Milano thanks to the support of the Falck Foundation and Italian Railways) in 2018, with the aim of planting 3 million trees by 2030 in order "to make natural capital grow, clean the air, improve the life of the great Milan and counter the effects of climate change". The project is supported by a scientific research activity, which has focused on various areas, starting with a mapping of the metropolitan area with the aim of recording the current state of urban trees and its dynamic evolutions. The Milan Plan has certainly had a great impact from the point of view of communication and dissemination, thanks to Stefano Boeri, an architect widely recognized in the international field; but above all because it is grafted onto a long-term communication strategy. Starting from the Metrobosco project (2004) introducing the notion of "vertical forest", and moving to the global success of Expo 2015 Milan, with the construction of the surrounding forest, and to the "Biblioteca degli Alberi" in the City Life district, the FORESTAMI project is based on an image and a narration of Milan as a truly green city.

3.2. Urban Forests and Street Tree Lines in Rome, Central Italy

The progressive "urbanization of forest landscapes"—i.e., the increasing mixite of residential settlements and small forest fragments (woodlots), mainly under tree-line designs—was well documented in Rome over the last 80 years (Biasi et al., 2015). Starting from facts and figures, these trends outline how urgent is, in such a territorial context, to initiate a complete rethinking of urban forestry policies, providing a comprehensive interconnection of policies within the rationale of green infrastructure [98,99], e.g., spanning from suburban forest conservation to implementation of tree streetlines into a broader green network of gardens, parks, and urban woodlots [100,101]. In this context, Rome is the largest municipality in Italy (1285 km^2) and likely in the European Union, with one of the most abundant stocks of tree lines, mainly pines and platans, that require increasing management, e.g., due to stability issues. Being in turn one of the most crowded cities in Italy, with population densities ranging between 20,000 inhabitants/km^2 in the historical city and 1000 inhabitants/km^2 in the suburbs, Rome represents a paradigmatic example of the continuous interplay between urban areas and trees/forests, which requires a coordinated policy to ensure a comprehensive planning and full management. In the following paragraphs, we considered Rome's municipality, as described above (Figure 1).

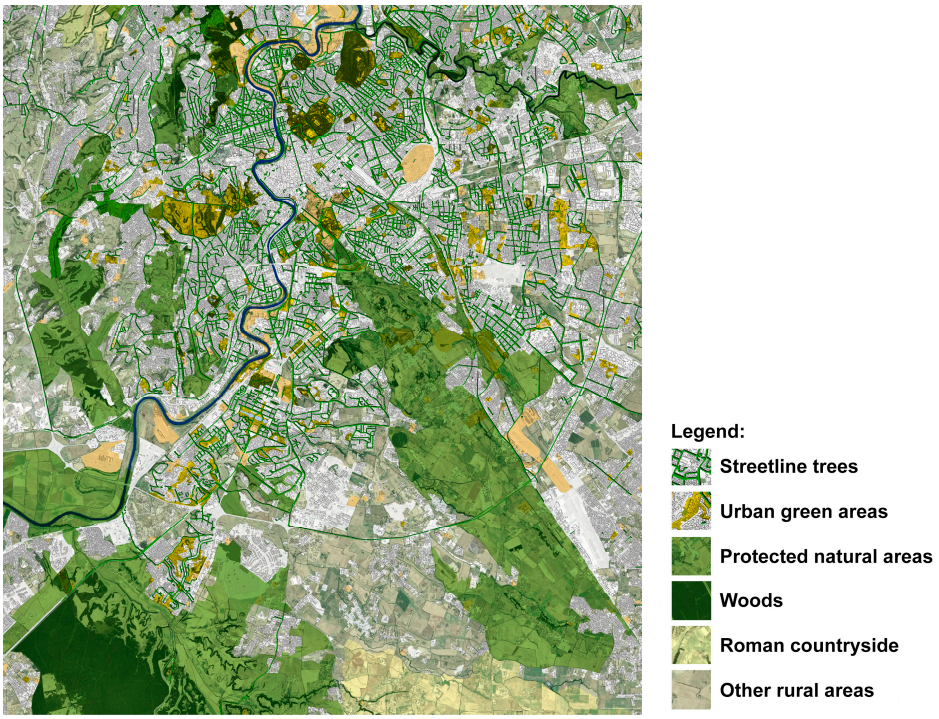

Figure 1. Selected information layers illustrating the main green areas of Rome's municipality (inside the great ring road), and the network of streetline trees (source: author's elaboration on Regional Territorial Landscape Plan cartography).

Built-up settlements in Rome expanded, covering 6.5% at the end of World War II and 27.5% in recent times. Forests experienced in turn moderate changes with a slight increase in both surface area (from 11.2% to 11.9% of the total landscape) and wood volume, despite a higher landscape fragmentation [102]. The inspection of comparable land-use maps documents how medium-high density settlements concentrated nearly 2% of forest cover in 1936, increasing to 8% in 1974 and 21% in 2018. From a morphological perspective, forest landscape in Rome was classified into 2092 and 2906 patches, respectively, in 1949 and 2008, indicating a progressive fragmentation of woodlands [66]. Patches classified as "islets" increased from 22.8% to 36.8% of the total forest surface. "Loop" and "bridge" morphologies also increased in number and surface, indicating a more complex landscape in 2008 [22,103].

Despite the fragmentation process of suburban landscapes due to settlement sprawl, Rome still presents as a green-spatially porous-city, with a large penetration of vegetation in the building fabric thanks to the permanence of the historical landscape of the Roman countryside [40], to the widespread presence of open areas of the archaeological and historical–cultural heritage, to the excellence of the coastal natural heritage, to the wrecks of the minor hydrographic network [101,104]. In a spatial planning perspective, it is even clearer how the Metropolitan city of Rome (5350 km^2) has a large natural capital, consisting of protected areas of significant value, nature reserves, urban parks, contiguous and interstitial agricultural land with respect to built-up settlements, fragments of widespread naturalness that contribute to the formation of the Provincial Ecological Network (PEN) or, in more general terms, of the "urban green system". This structure is represented in the cartography of the PEN included in the General Provincial Territorial Plan of metropolitan Rome (2010), then replaced and integrated with thematic and interpretative maps of the landscape characteristics within the Regional Territorial Landscape Plan (PTPR) currently enforced in the law.

Maps highlight the selected and relevant characteristics of the metropolitan landscape in Rome. The urban structure of the building fabric, starting from a dense nucleus,

innervates on the consular roads moving radio-centrally from the historic town (i.e., within the Aurelian Walls constructed in ancient Roman times). This radial morphology created a sort of settlement tentacles that continue well beyond the great ring road highway bounding the consolidated city and joining the surrounding rural settlements and medium-sized towns with central settlements. In this complex structure, there was space for a large penetration of green spaces and natural areas, starting from the Tiber river basin, which opens toward the mouth like the "tail" of a "comet", together with the Tenuta di Castel Porziano, up to the Archaeological Park of the Appia Antica which is wedged up within the historical fabric of the city to the south-east, to the areas of great naturalistic interest on the different radial lines. In this perspective, high-quality forest fragments include Turkey oak, hornbeam, English oak, and evergreen woods in the Insugherata Nature Reserve; the remarkable cork forests of the Pineto Regional Urban Park; the small forests of Turkey oak with cork oak specimens in the Tenuta dei Massimi Nature Reserve; and oak woods and more hygrophilous species along the river (e.g., elm, white willow, ash, maple) in the Aniene Valley Nature Reserve [98,101].

4. Opportunities and Constraints in Designing Forest Streetscapes: Evidence from Rome

From a perspective of urban forestry, a tighter look to the street tree lines' characteristics in the "eternal city" is particularly appropriate here. The arboreal heritage of the road network of the municipality of Rome alone has about 165,000 trees, according to an estimate updated in 2016. It can be seen how the network of tree-lined streets binds to the vegetated areas of the city, building an integrated and connected system, with great opportunity to work on its implementation, tying the porosity of the building fabric as in a mesh. Trees in Rome constitute an element of strong identity: from plane trees, to lime trees, to umbrella pines, to cypresses, the tree-lined roads characterize streets and neighborhoods, speak of specific historical periods and tell pieces of the city's history. Examples of the ornamental trees in Rome include (i) the archaeological green of the new Rome (upper left), with the hundreds of umbrella pines and (ii) the public space of the "passeggiata archeologica" park which still constitutes the image of the Roman landscape from Coliseum to Caracalla baths (upper right) and (iii) the 80,000 plane trees planted by the Savoy kingdom on the new unitary capital with the aim of characterizing the landscape of great urban connecting boulevards, such as the "Lungotevere" (street along the Tiber river, lower left) and many other roads (Figure 2) radio-centrically moving from the center to the periphery (upper right).

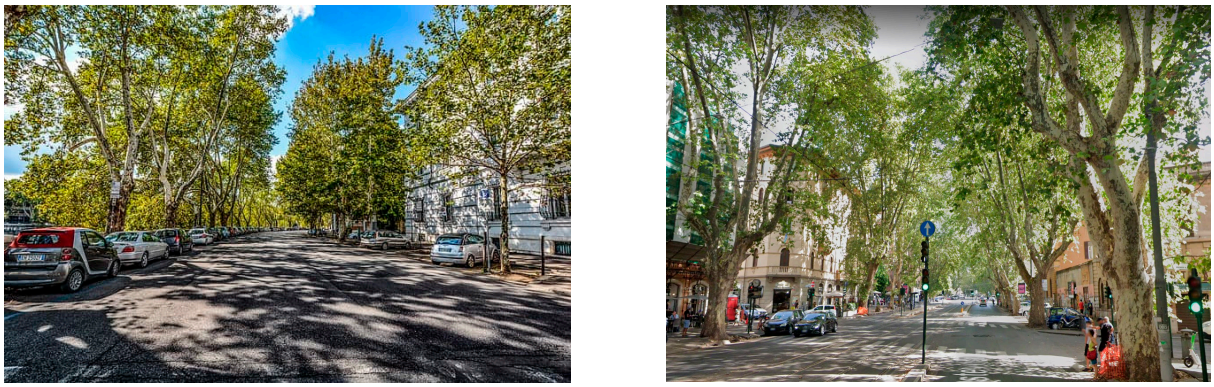

Figure 2. Examples of ornamental street tree lines in central Rome (Source: author's photographic archive, 2022).

Despite the original motivation underlying tree planting in Rome, especially in the 19th century, the examples in Figure 3 show a particularly differentiated morphological landscape even in the historical center of Rome, going sometimes beyond the mere ornamental, aesthetic, and scenic perspective. The road trees can interrupt the continuity of the compact and hyper-dense urban fabric, without however ensuring that integrated network of green structures, highly fragmented but at the same time ecologically valid (upper left). Tree lines, despite being extensively distributed in the landscape scene, may in turn be the only sink of green open spaces (upper right). Being less extensive, tree lines may link road trees with private enclosed gardens, tree-lined squares, small public parks, and other green areas not specifically aimed at specialized public use, such as sports and recreational areas, but with the presence of organized green areas (lower left). Finally, the absence of tree lines in peripheral districts, despite a less crowded settlement, may create the same conditions of "urban desert" typical of central cities, thus representing crucial landscape elements for habitat connectivity in downtown Rome.

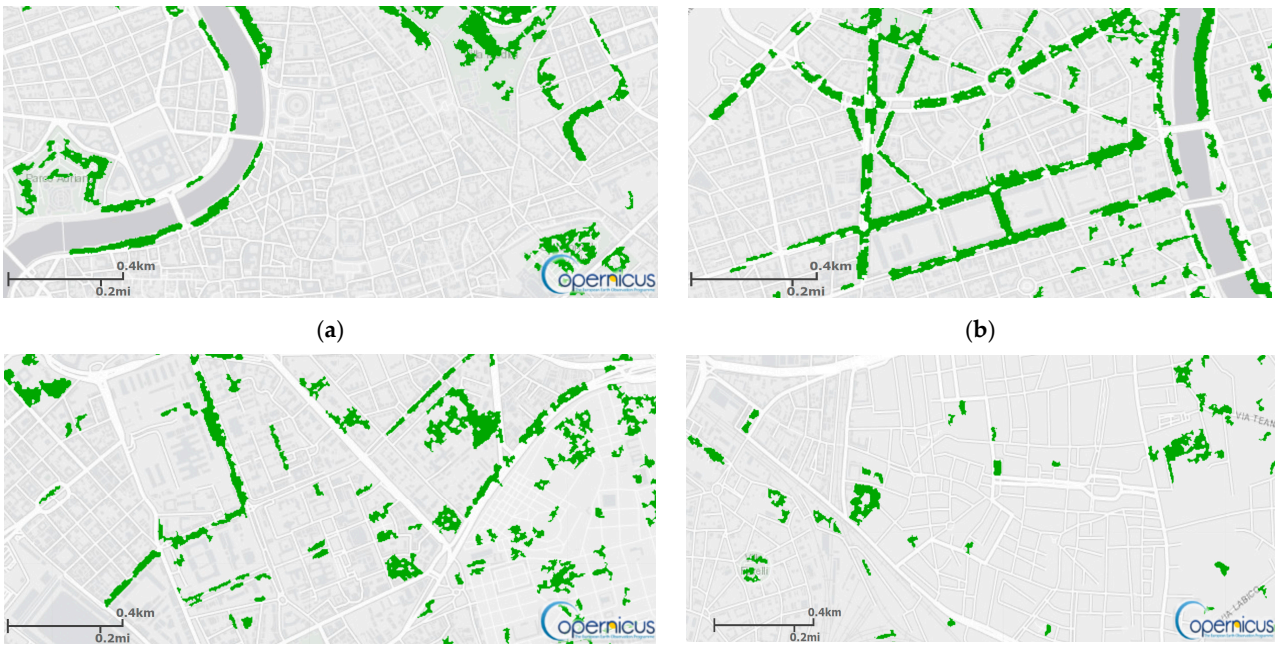

Figure 3. Spatial distribution of tree line forestscapes in selected neighborhoods of Rome; four examples of the ground morphology of street tree lines taken from the "street layer" of Copernicus remote sensing high-resolution monitoring of urban landscapes in Europe (source: author's

elaboration on specific shapefiles covering landscape scenes in central Rome, taken from Copernicus Urban Atlas European Environment Agency website, 2018). (**a**) The historical settlements in Rome's center (the role of tree streetlines along the river Tiber is highlighted in a complete built-up matrix). (**b**) The design of 19th century residential settlements ("Prati") north-west of the historical center, where green spaces are exclusively associated with tree streetlines. (**c**) The interconnection of short tree streetlines and small gardens in a residential-service (high-density) settlement east of the historical city. (**d**) The absence of tree streetlines and the lacking interconnection with woodlots and private gardens in a (medium-density) residential-industrial mixed settlement ("Pigneto") in the periphery east of Rome.

From a political perspective, Rome has launched an Urban Forestry Plan with the aim of planting 1 million new trees in the next few years, covering both the Rome metropolitan area (the former province of Rome with 121 municipalities) and, more specifically, the territory of Rome municipality, including the historical settlements and a vast portion of the surrounding "Agro Romano". The plan adopts a landscape ecology perspective, considering the changes over time in shape and fractal dimensions of urban woodlots, considering in turn the increased discontinuity of the woodland matrix [103]. Based on the official statistics of Rome's municipality [105], Rome's forestation plan (2012) involved 231 plots covering 1848 hectares of land (Table 1), with an average size of the plots of 8.0 ± 12.0 hectares and a median size of 3.7 ha. Unfortunately, the distance from downtown Rome indicates that the main interventions were concentrated in suburban plots/streets/areas, possibly demising the issue of aesthetic landscape conservation downtown.

Table 1. Statistics from Rome's Forestation Plan (2012) adopted by the municipal council (source: author's elaboration from Rome's municipality official statistics).

	No. Patches	**Surface Area (ha)**	**Average Size (ha)**
Sites involved	231	1848.0	8.0 ± 12.0
Land tenure			
Common	187	1408.9	7.5
Private	43	427	10.0
Private (% in total landscape)	18.6	22.9	-
Distance belt from central Rome			
Consolidated city (<10 km)	66	445.8	6.8
Suburbs (>10 km)	165	1402.2	8.5
Suburbs (% in total landscape)	71.4	75.9	-

As a contribution to urban sustainability, however, the forest plan argued that an efficient policy approach should promote increasing forest cover and patch connection together with a reduction in patch fragmentation [106,107]. Assuming the protection of relict woodlots and tree streetlines as a priority target for sustainable land management in urban contexts, spatial planning in Rome proved to be increasingly required to preserve and re-connect urban green (small) public and private patches, with streetlines of pinewoods and broadleaved species into a green network embedded into the urban matrix. It is evident how tree streetlines are the best patch ecologically connecting these dispersed but high-quality landscape elements [108]. Urban expansion has impacted the ecologically fragile forest landscape of Rome. In this perspective, it should be taken into account that pinewoods represented the most peculiar landscape element in the area [40,45].

The creation and valorization of a structured network of "streetline forestscapes" is particularly appropriate in a context with a moderate expansion of urban forests that can be envisaged in the recent history of Rome. These targets represent integrated measures in a sustainability strategy protecting fringe forests [109]. Actual planning in Rome goes in this direction only in part. As a matter of fact, compared with the explicit results of a number of landscape analysis exercises, spatial planning concentrates on fringe land,

improving geographical connectivity of peripheral woodlots, especially along waterways, and demising central settlements and the potential of street tree lines therein. In this perspective, the forest plan in Rome should remove (or at least contain) all the negative elements making forest patches vulnerable to further fragmentation (e.g., avoid conversion to even more isolated "patch" elements). Landscape complexity and the level of coordination/multi-scalarity adopted by urban forestry plans, such as the Rome planning, primarily influence the effectiveness of measures promoting urban containment and reducing land fragmentation.

5. Discussion

Urban forestry development plans, which are often considered under the broader "concept" of urban forestry, are a great opportunity for our cities [58,93]. Improving urban forestscapes is a successful part of this strategy, since these are concrete actions turning the paradigm of sustainable urban development into concrete measures in support of citizens' well-being [88], not only addressing environmental challenges through mitigation works, but also implementing the quality of public space in our cities [85]. However, the risk is that of not fully seizing the opportunity offered by major investments and only being taken by the aesthetic appeal of urban greenery. Nor can the question be posed in terms of quantities of slogans: one million, two million, or three million more trees.

First of all, the definition of forest carries with it a minimum size criterion of 0.5 hectares and when speaking of "urban forests" the term must be used with a certain caution and awareness. Then, the forest carries within itself an evolutionary idea of forest succession, whereby the new formations of trees are not mere plant additions in the urban context, but "pioneer" species capable of triggering an evolutionary process [73,81]. The experience of Rome is thus fundamental to give due weight to the different roles of road trees in the ecological, architectural, engineering, and social fields, differentially considering some aspects relevant to urban forestation plans and in particular in projects for the new planting of road trees.

The first aspect concerns the issue of road trees as part of the green system. The trees, even when they are arranged in rows along a road, together with the vegetated areas of the city, constitute the "green system", linking the porosities of the building fabric with a mesh, with beneficial contributions in terms of ecosystem services. It is therefore necessary to consider the issue of road trees within the more general question of the structure of urban and metropolitan green areas, which includes urban parks, ecological corridors between wilderness areas, residual green areas of buildings, riparian strips of rivers, agricultural areas, as well as natural and wooded areas [17,61]. The project of new plantings and replacements of existing trees should follow a careful analysis of the local and regional ecological network, but also of the various urban and territorial systems which it overlaps [107]: the mobility network, the service system, and the city public spaces, including urban parks, as well as vacant, compromised areas.

In particular, information on the natural heritage, hydro-geomorphology, historical-cultural heritage, and environmental criticalities must be considered and integrated in order to understand where and how to carry out the interventions. The strategy promoted by urban forestation plans, and in particular tree-lined roads, should work in synergy with the other requests for urban redevelopment and landscape enhancement of the city, taking into account the presence of other plans and requests, which concern cycle and pedestrian mobility, the reconnection of urban parks, the management of water resources, as well as the system of private space and public services [16].

Second, trees have a great landscape and identity value in building the image of a given city. In particular, the trees arranged in rows along the urban streets represent a perceptual element of great importance in the urban scene, providing a strong identity connotation, which makes places recognizable [36]. The strategic plan for the implementation and management of road trees therefore constitutes an important tool for the ordinary care of the tree heritage (through replacement, renewal, and expansion

interventions), and a great opportunity to improve the quality of public space [8,28]. The planting of new trees, which corroborates the regeneration of the urban space [5], has low plant costs compared to the implementation of extensive area interventions, not only with paving, but also with turf to be irrigated and maintained. In this perspective, the theme of street trees also becomes a landscape theme of urban design, or in particular of streetscape design [46,51].

The case study perspective finally makes evident the need of relating the plans of road trees with the design of sidewalks, and to systematize the forestation plan with the green plan, including urban parks and protected areas. Policy coordination and planning instruments integration remain—especially in countries with a past experience of building informality and chaotic urban expansion, such as those of Northern Mediterranean basin—the pivotal issue in any successful strategy of urban forestry.

6. Conclusions

The development of streetline forestscapes in any city should coupe with the locality of vegetation, environmental characteristics, public demands, as well as synergy and trade-off among main ecosystem services of street trees. The implementation and replacement of road trees, more generally in urban areas, should be tackled in an intelligent and non-massive, pioneering and non-definitive manner, admitting the criterion of age diversity, together with that of the heterogeneity of form and typologies, where healthy and vigorous plants can be alternated with those of different ages. From these considerations, the planting of new trees in our cities could have a great impact in ecological and environmental terms, especially if they are carried out in the capillary network of urban roads, where the phenomenon of the heat island or rainwater outflows create more damage. The project of planting and replacing the tree-lined roads, with all its critical issues, also brings the great opportunity to be able to face a redesign of urban sidewalks, with a real impact on the quality of public space. More specifically, this is a question of relating the plan of the road trees, with the project of the sidewalks with urban supplies and, at the same time, to systematize the street forestation plan with the green plan, which includes urban parks and protected areas, integrating it with that of sustainable mobility and public services.

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