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Urban forests, global change and their role in city sustainability[1][2]

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Abstract

Le foreste urbane, considerate come la somma totale di tutti gli alberi nelle aree urbane e nei dintorni e gestite come un "baldacchino" urbano, sono spesso il tipo dominante di infrastruttura verde nelle città. Il ritmo del cambiamento a livello locale e globale, tra cui l'esaurimento degli ecosistemi, la migrazione della popolazione guidata dal clima, gli eccessi simultanei e le carenze idriche stanno esercitando enormi pressioni sulla capacità di adattamento delle città. Gli alberi sono considerati una delle numerose soluzioni *go to* per affrontare le sfide attuali e future. Tuttavia, la crescita urbana sta mettendo sotto pressione gli alberi. Lo spazio terrestre è finito, i suoli urbani sono spesso trascurati e la carenza di acque sotterranee sta influenzando negativamente la crescita degli alberi, anche rendendo gli alberi vulnerabili alle malattie. Tuttavia, gli alberi possiedono una notevole resilienza e le loro proprietà nel ciclo dei nutrienti, nella gestione del carbonio e nel rendere la vita urbana più sopportabile sono generalmente riconosciute. Per soddisfare le esigenze degli alberi e permettere loro di dare un contributo nel contrastare l'emergenza climatica, i progettisti devono fare spazio agli alberi, gestire i suoli urbani e le acque sotterranee risorse preziose, e mettere gli alberi alla pari con le altre grandi infrastrutture nel processo decisionale e nell'allocazione del budget. Le linee guida per la silvicoltura urbana nel prossimo secolo dovrebbero presentare nuovi capitoli, tecnici e non tecnici. Il "tecnico" comprende scelte sagge delle specie ed evitare la monocultura a tutti i costi, una migliore gestione del paesaggio stradale, il rispetto per il substrato (suolo urbano), il miglioramento delle acque sotterranee e la gestione del micro-habitat. Il "non tecnico" include riforme istituzionali e delle risorse, sostenendo il ruolo dei cittadini come amministratori degli alberi e una migliore considerazione degli alberi come infrastrutture verdi tra i professionisti urbani.

Urban Forests, considered as the sum total of all trees in and around urban areas and managed as an urban canopy, is frequently the dominant type of green infrastructure in cities. The pace of change at the local and global level, including the depletion of ecosystems, climate driven population migration and simultaneous excesses and deficiencies in water are putting immense pressures on the capacity of cities to adapt. Trees are being looked to as a one of several 'go to' solutions to meet current and future challenges. However, urban growth is putting pressure on trees. Ground space is finite, urban soils are frequently neglected and ground water shortage is adversely affecting tree growth not least by making trees vulnerable to disease. Nevertheless, trees possess remarkable resilience and their properties in nutrient

cycling, carbon management and making urban life more bearable are generally recognised. To meet the needs of trees and to allow them to make a contribution to tacking the climate emergency, urban planners need to make space for trees, manage urban soils and groundwater as a precious resource and put trees on a par in decision making and budget allocation with other major infrastructures. Guidelines for urban forestry in the coming century should feature new chapters, technical and non-technical. Technical includes wise choices of species and avoidance of monoculture at all costs, better street scene stewardship, respect for the substrate (urban soil), groundwater enhancement and micro-habitat management. Non-technical includes institutional and resource reforms, championing the role of local citizens as tree stewards and enhanced education in trees as green infrastructure among urban professionals.

Parole chiave / *Keywords*

Emergenza climatica, Forestazione urbana, Green Infrastructure, Servizi ecosistemici, Suoli urbani / *Climate emergency, Urban forestry, Ecosystem services, Green infrastructure, Urban soils*

Trees and urban forests

For many cities and urban areas, trees including woody shrubs are notable elements of their open space. Trees are solitary organisms but when considered collectively they become component parts of urban green infrastructure networks which, along with buildings and grey infrastructures such as road and rail, make up most of the urban landscape. Urban trees are found in all sorts of locations including private gardens, on roadsides, in public spaces such as urban parks, in semi-natural areas, woodlands and in some cities in large forests. Not all urban trees are planted as some are self-propagated, taking advantage of open soils, natural seed dispersal and man-made soils. Railway sidings, former industrial sites, municipal landfills and old quarries may have verdant naturally regenerating trees within them. Tree cover in urban areas varies enormously; the factors determining this can be localised and historical. Climate, soil quality, landform, land use planning (or lack of it), cultural and heritage sensibilities are contributors to this. In Europe urban tree cover ranges from less than 5% to well-over 50% in some cities [Casalegno 2011]. Research in the United States has shown that urban tree cover is in decline, especially when open spaces are lost to new development [Novak and Greenfield 2018].

To understand the impact of trees on city sustainability it is helpful to have some broadly accepted definitions in place, in particular to understand their role 'collectively' rather than 'individually'. In this regards the term Urban Forest is most often used and this can be considered as a collective noun describing all the trees in and surrounding the city. The term Urban Forestry is also encountered and can be considered as the management of the urban forest as a 'whole'. Conceptually it is helpful to consider the Urban Forest as an overall 'tree canopy for the city'. Another term encountered is arboriculture which is frequently used to describe the practice of managing individual trees. It should be noted that to some extent all these terms are contestable. Urban Forest(ry) as a term,

first appeared to any extent in relation to North America [Konijnendijk *et al.* 2006], but the roots of urban forestry can be traced back many centuries, arguably to the dawn of human civilisation, when settlements first formed, and people planted and harvested trees in foundling towns for food and fibre. Since the footprint of an urban area extends beyond the limit of built development, the neighbouring environs close to cities can include large areas of tree cover used in a multi-functional sense for recreation, nature conservation and commercial tree cropping [Konijnendijk and Gauthier 2006]. In respect of these the term peri-urban forest is sometimes encountered, and these can be physically linked to cities through green infrastructure corridors.

The challenges of the modern urban world

The modern world is becoming ever more urban, a trend that is set to continue [World Bank 2020]. Global population is expected to grow until at least the middle of this century as more and more people migrate to urban areas [European Commission, n.d.]. In the developing world this expansion can be unregulated leading to critical infrastructure difficulties. In more developed societies where regulation is stronger, policy makers attempt to manage this process through urban densification [Wang *et al.* 2019]. The consequences of densification are the loss of open space and the sealing of soils to the detriment of urban tree cover [Wang *et al.* 2019]. If the problems caused by population growth and urban expansion were not sufficient there is the added difficulty of anthropocentric climate change [Rahmstorf 2008]. The changing climate is stressing the environment to breaking point leading to catastrophic flooding, major droughts, population emigration from badly affected regions such as east Africa as well as major costs to national economies and tragically loss of life. For these reasons those engaged with urban forests have begun to look at the resource of trees in cities in a new way as nature-based thinking [Randrup *et al.* 2020]. In particular the role of trees and the urban forest as a nature-based solution (Uf-Nbs) is being emphasised [Roeland *et al.* 2019]. At the individual and collective level trees already have a great impact on the city, not least because they are highly valued in the urban landscape due to their aesthetic qualities [Shackleton *et al.* 2015]. For this reason, they are planted in new developments, within public parks, as street trees in boulevards and in arboreta, to enhance the 'street-scene' and the marketability of new developments. Even so the gains are all too often outweighed by the losses.

Urban Green Infrastructure and Urban Forest Nature Based Solutions

The advent of green infrastructure (Gi) as an urban planning concept over the last thirty years has seen an increasing discourse on the role of trees in Gi planning [Lafortezza *et al.* 2013; Pauleit *et al.* 2017]. The European Green surge project is helpful in this regard as it discerns four planning principles, namely green-grey integration, connectivity, multifunctionality, and social inclusion, and four important policy challenges that can be addressed through Gi planning, namely biodiversity protection, climate change adaptation, promotion of the green economy, and social cohesion [Davies

et al. 2015]. These planning principles and policy challenges are helpful in considering how urban forests can address issues of city sustainability. Two notable areas stand out where urban forests can make a major contribution, firstly through connectivity and secondly through multifunctionality. Considering urban trees multifunctionally is not new, however, as is evidenced by urban trees planted for amenity purposes and simultaneously for shade provision, but their wider services can be underestimated.

The term Urban Forest Nature Based Solutions (Uf-Nbs) is a recent addition to the green infrastructure vocabulary. It can be considered as a subset of nature-based solutions [Fink 2016] that build on tree-based urban ecosystems to address societal challenges, simultaneously providing ecosystem services for human well-being and biodiversity benefits [Clearing house Dow2018]. Trees achieve this through their normal biotic processes and their abiotic presence. When trees are considered collectively as an 'urban forest' the benefits sometimes accumulate exponentially. The Millennium Ecosystem Assessment [Mea 2005] and the concept of ecosystem services is a good point of embarkation when considering the role of the urban forest in city sustainability along with the planning principles and policy challenges derived from the Green surge project. The urban forest can make a significant contribution to all the main groupings of ecosystem services (supporting, provisioning, regulating and cultural services), both in respect of well-being and biodiversity. This is illustrated in figure 1 and figure 2.

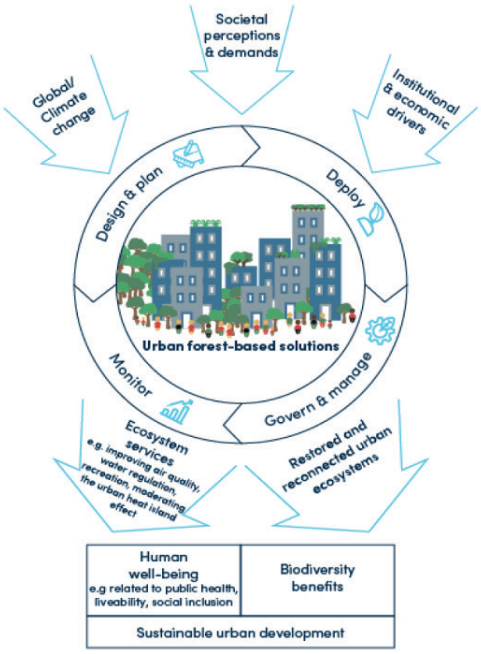

Fig. 1. An overview of Urban Forest Nature Based Solutions as proposed in the Sino-European Clearing House project.

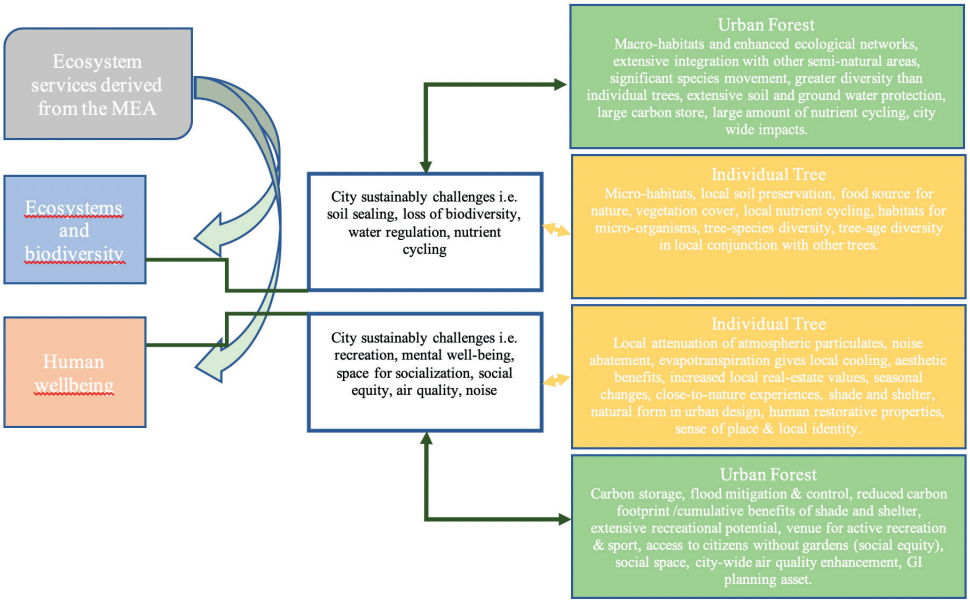

Fig. 2. The urban forest can make a significant contribution to all the main groupings of ecosystem services in respect of human well-being, ecosystems and biodiversity (authors own). Mea, Millennium Ecosystem Assessment.

Trees, urban forests and the delivery of ecosystem services

For the most part trees need little more than space, access to groundwater and light to deliver their biotic benefits and hence their ecosystem services. However, the urban environment is hostile to trees and they are often stressed reducing their life span and environmental performance [Johnston and Percival 2012]. Some of the most notable difficulties result from road salt, structural integrity due to limited root space, underground services, soil compaction and increasingly pests and disease allied to global trade [Johnston and Percival 2012]. Neither is it uncommon to find trees in inappropriate locations, where they might be a hazard or occasions where certain tree species have been specified even though they are known as high emitters of pollen allergens [Asam *et al.* 2015; Cariñanos *et al.* 2019]. Tree strategies can also focus too much on the individual tree and too little on the urban forest. This is sub-optimal when it comes to Uf-Nbs, as the incremental gains come from many trees connected together and these working alongside other Gi approaches including grey–green co-interventions [Landscape Institute 2009]. A co-intervention of this type can be illustrated by the creation of off-road cycleways where tree avenues co-created with them provide cyclists with shade, wind attenuation, noise limitation and visual separation from other adjacent infrastructure such as roads whilst also providing biodiversity connectivity. Retrofitting this into existing neighbourhoods can be challenging but is entirely plausible in new neighbourhoods or where large-scale redevelopment is occurring.

Urban forestry and city sustainability

City sustainability encompasses many social and economic factors. Uf-Nbs can be significant in this regards. Lifelong learning and education in environmental sustainability is one such area. Education of the urban populace on understanding the role that nature can play in making their communities sustainable will be essential to the general acceptance of nature-based solutions. Without public support budget holders will revert to tested grey infrastructure methods, through the practice of 'path dependency' [Davies and Lafortezza 2019]. Grey infrastructure construction is often very visible, and this gives the appearance of 'action being taken'. Citizens need to 'believe' that investing in green infrastructure is as valid an approach and this is where education is imperative. In this respect trees have something of an advantage because their physical presence is soon noted when they are grouped together, and they are tactile from seed to mature tree.
Uf-Nbs education does not describe a 'classroom' experience but can sometimes be allied to it as is the case with Forest Schools (https://www.forestschoolassociation.org; accessed 22 April 2020). It is a participatory approach where citizens can directly engage with tree planting and care. A particularly interesting example is the 'Orbital Forest' of Tirana, Albania, which is leading towards the planting of an estimated 2Mn trees largely by volunteers; this is being done through a combination of political leadership and innovative measures such as smart incentives and a temporary tax instrument [Sustainable Cities Platform, n.d.]. This project exemplifies the relationship between Urban Forestry and City sustainability as it emphasises the need to create an actual physical green belt and highlights the role of the orbital forest in terms of air pollution control, CO2 production, soil erosion control, soil fertility amongst others, and economic and territorial enhancement of some 14,000 hectares of land [Sustainable Cities Platform, n.d.].

The Sino-European Clearing house project [Clearing house DoW, 2018] has identified two notable interactions, amongst others, that can be considered as vital to the future uptake of Uf-Nbs in city sustainability. Firstly, the need to understand how Uf-Nbs interact with the complex urban socio-ecological systems that exist in urban areas; and secondly, how transdisciplinarity and co-design can be made to work to ensure the uptake of Uf-Nbs. These are important with regards to the resilience agenda that city administrations are addressing including the preparation and adoption of climate adaptation strategies. Set against the long-term economic impact of the Covid-19 pandemic, resources for climate adaptation may be severely limited for years to come. Uf-Nbs offer a cost-effective way of delivering climate adaptation interventions in a resource-limited environment. Uf-Nbs can be characterised as low upfront costs and long lasting, but have the disadvantage that performance takes many years to accumulate as the biomass of trees is in proportion to the ecosystem services a tree or entire urban forest provides [Hale *et al.* 2015]. Indeed, it may take 50 or more years for the ecosystem benefits of an urban forest to be optimised. On the other hand, grey infrastructures have high upfront costs but are generally shorter lasting, and their benefits can be immediate. This is where co-design can be significant by developing new innovations which combine budget-limited grey approaches with the longevity of Uf-Nbs, with stakeholders, citizens, political leaders and infrastructure delivery companies. Public budget holders in particular have a key role by favouring biophysical green

procurement.

Discussion

Faced with a heightened awareness of climate change resulting from global protests such as the School Strikes, trees have become a 'go to' solution to policy makers responding to declarations of a climate emergency. Whilst this is to be welcomed it can be a blunt instrument and unfocused. The 'right tree in the right place' and a long-term commitment to management of the urban forest are key considerations. A debate is needed on whether densification of cities and the resulting loss of greenspace that comes with it is really a sustainable strategy, not least because the one thing that trees and other forms of biophysical Gi need is 'space to live'. This is a notable challenge given that city densification has become accepted wisdom in urban planning not only in Europe but globally as well. The notion that we may have to let city boundaries expand to give living space to trees and other organisations represents a seismic change. However, this is not new, historical cities such as Cologne in Germany have preserved well-wooded green rings as the city expanded beyond. Hence new green tree belts such as that presently underway in Tirana may one day become an 'inner forest ring' should extensification replace densification in an attempt to use nature-based solutions to manage city problems.

All that trees need to act as an Uf-Nbs is space, water and light to perform their biotic role and creative people to exploit their abiotic presence for education, public well-being and close to nature living. Trees are remarkable living organisms and already have a major role in city sustainability. Nature based thinking and Uf-Nbs provide a direction of travel that addresses key aspects of urban Gi planning and policy. Co-designed with grey infrastructure the urban forest can meet challenges relating to urban flooding, through the properties of shade and evapotranspiration they provide, urban cooling in summer and wind speed reductions in winter. Trees fix carbon dioxide in their biomass, recycle soil nutrients, provide macro- and micro-habitats and when linked together as an urban forest provide Gi connectivity, educational opportunities, and health and wellbeing benefits among others.

To meet the needs of urban trees and to allow them to make a contribution to tacking the climate emergency, urban planners need to make space for trees, manage urban soils and groundwater as a precious resource and put trees on a par in decision making and budget allocation with other major infrastructures. Guidelines for urban forestry in the coming century should feature new chapters, technical and non-technical. Technical includes wise choices of species and avoidance of monoculture at all costs, better street scene stewardship, respect for the substrate (urban soil), groundwater enhancement and micro-habitat management. Non-technical includes institutional and resource reforms, championing the role of local citizens as tree stewards and enhanced education in trees as Gi among urban professionals.

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