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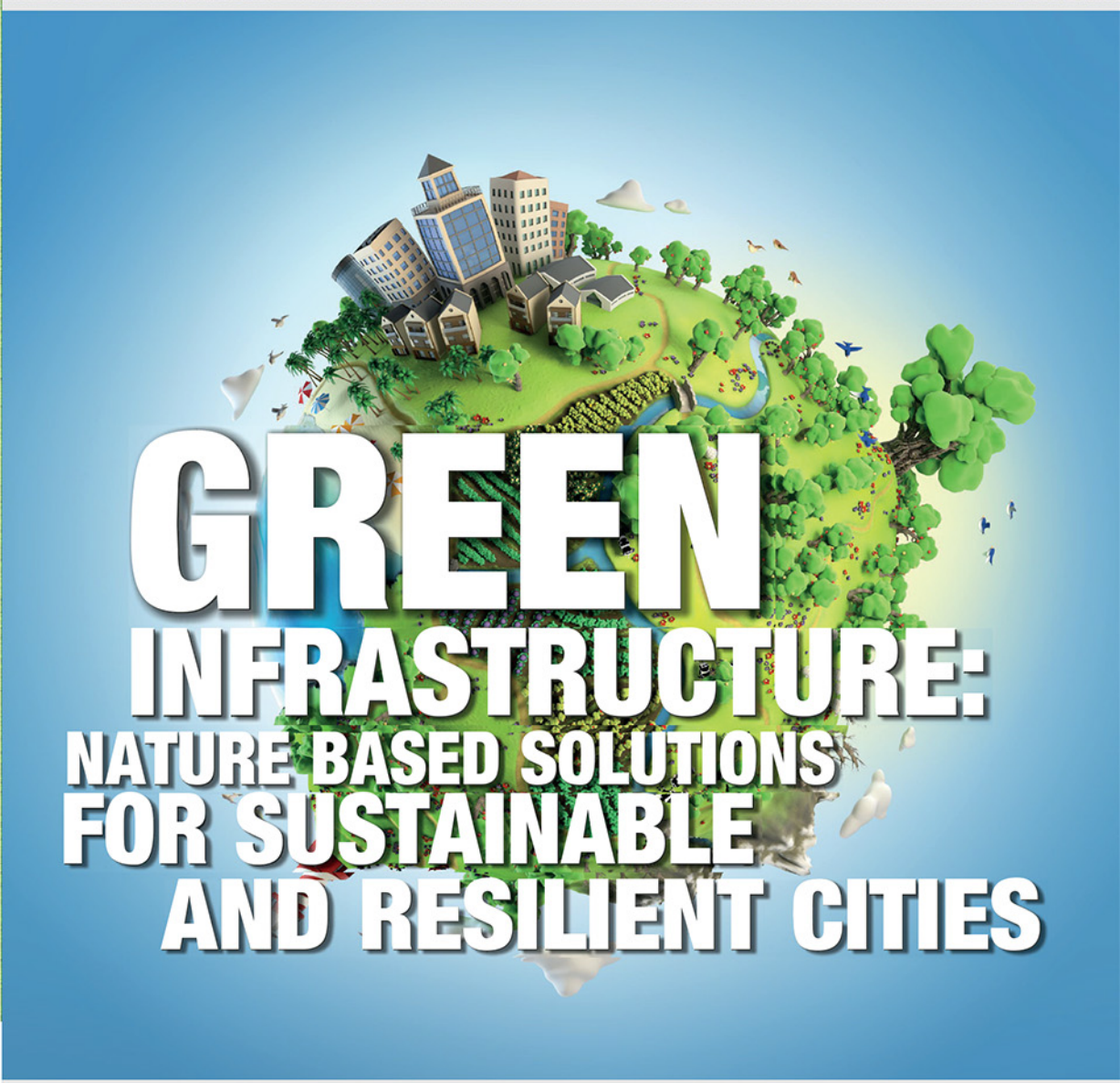

GREEN INFRASTRUCTURE: NATURE BASED SOLUTIONS FOR SUSTAINABLE AND RESILIENT CITIES

BOOK OF ABSTRACT

BOOK OF ABSTRACTS

Edited by Lucia Cherubini, Michele Mattioni, Concetta Caccavale (CNR-IBAF)

Welcome to Orvieto!

Quality of life in European cities and in most of the world is decreasing due to an increase of pollution levels, increase of heat islands, decreased biodiversity, flooding and extreme events also related to climate change. This can have detrimental effects for human health and well-being. At the same time cities are a large source of carbon and only a few attempts are underway to improve carbon sequestration at local level.

Green Infrastructure (GI) with particular focus on **Urban Forests** can contribute to the improvement of the urban environment through a number of mitigation actions. This is especially valid for the tree component of vegetation due to larger biomass and extended canopies.

The improvement of environmental and social/health conditions will lead to a long-term improvement in health conditions of populations, because of an improved urban environment (clean air, less polluting elements, less noise pollution) and better quality of life (more leisure opportunities, less stress, increasing social cohesion).

We expect people living/working in urban areas can take advantage of innovative **Nature Based Solutions (NBS)** which have GI as a main component, promoting them to other citizens and to other cities, along the lines of large investments such as the H2020 framework programme on this topic.

New models of **governance** for urban areas will also bring new ways of managing them, using new forms of rights and duties divided between owners and managers, as well as new forms of management. This can lead to decreased costs for planning and management and better efficiency of areas, which can contribute to economic growth.

The main objective of the Conference is to show how a trans-disciplinary approach to **urban planning** based on GI as NBS will enable maximization **Ecosystem Services** provision making future cities more **resilient** and **sustainable**.

The Conference will bring together urban foresters, landscape architects, arborists, plant physiologists, ecologists, economists, epidemiologists, sociologists, students, urban planners and managers and enable different communities such as researchers and academics, practitioners, policy makers, administrators, and the private sector to exchange knowledge and insights.

Carlo Calfapietra, Chair of the Conference and of the COST Action FP1204 "GreeninUrbs"

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SCIENTIFIC SESSIONS
INDEX

PLENARY SESSIONS

Keynote Speaker
EU H2020: Promoting innovation with Nature to address societal challenges and enhance sustainability and resilience

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Human societies are facing a broad range of challenges in urban, rural and natural areas: climate change, unsustainable urbanisation etc. There is convincing but fragmented evidence that innovating with nature through nature-based solutions can provide cost-effective solutions to overcome many of these complex and highly-interdependent societal challenges.

H2020 - the EU R&I Framework Programme - and more particularly its Societal Challenge 5 on "Climate Action, Environment, Resource Efficiency and Raw Materials" invests on providing evidence about nature's innovation potential as a means to transform societal challenges into innovation opportunities, promote green growth and jobs and support transition pathways towards resilience, sustainability and resource efficiency. Multi-disciplinary and multi-stakeholders partnerships, open access data platforms, systemic approaches and solutions encompassing all forms of innovation (technological, digital, social, institutional, financial, regulatory and governance) are being promoted.

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Keynote Speaker
The Green Infrastrucure Strategy of the European Commission

*Julie Raynal**
DG Environment, EU Strategy on Green Infrastructure

Green Infrastructure is a strategically planned network of natural and semi-natural areas that delivers multiple functions, services and benefits on the same spatial area, to enhance human well-being and quality of life in urban and rural areas. In other words, Green Infrastructure harnesses the creative, protective, provisioning and adaptive forces of nature in a cost-efficient way, working with nature and not against it.

This is the objective of the EU strategy on Green Infrastructure, adopted in 2013, which aims to ensure that the protection, restoration, creation and enhancement of green infrastructure become an integral part of spatial planning and territorial development whenever it offers a better alternative, or is complementary, to standard grey choices. Among the implementing actions of this Strategy, the EU is improving he knowledge base on ecosystems and ecosystem services provided by GI, including in cities; is mainstreaming GI in Urban policy; and is currently exploring the opportunities of developing a trans-European Green Infrastructure initiative, with a view to scaling up the deployment of GI throughout Europe.

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Keynote Speaker
Green Infrastructure: when Joint Progamming Initiative promotes and funds nature based solutions for sustainable and resilient cities

*Paola Clerici Maestosi**
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Cities are wonderful vibrant places for education, employment and commerce, social encounter and recreation; they are the nerve centres of the modern global economy.

This concentration of economic and social activity is matched by a similar concentration in the metabolism of energy and materials as well as of technology and infrastructure, with consequences for raw materials depletion, greenhouse gas emissions and climate change; likewise a concentration in societal challenges.

And this concentration brings – also - considerable opportunities: improving the liveability of Europe's towns and cities we can improve the liveability of its urban majority; reducing the dependency on non-renewable energy and materials of Europe's urban areas and increasing the efficiency with which these resources are metabolised, we can achieve our greenhouse gas emission reduction targets.

Understanding how to move forward governing these challenges, for the diversity of Europe's cities and in their local contexts, asks for ambitious research programmes, as well as technological and innovation development.

It was against this backdrop that the Joint Programming Initiative Urban Europe was initiated in 2011.

In parallel with launching two pilot research funding calls and two ERA-Net scheme calls, the process of developing a Strategic Research and Innovation Agenda (SRIA) and a Research Roadmap have been set up and completed. And the nature based solutions for sustainable and resilient cities is one of the point of views towards the cities of tomorrow.

An overview about the contributions of JPI UE to the topic will be given.

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Keynote Speaker
They pave paradise... (How) Can cities turn green again?

*Holger Robrecht**
Deputy Director ICLEI Europe

"Our struggle for Global Sustainability will be won or lost in cities," previous UN Secretary-General Ban Ki Moon said on 23. April 2012 in front of local and regional leaders UN event in New York. He did so following an analysis of 21st century challenges identified by UN that starts by population growth, focused on poverty alleviation and continued into list of key words, each of the representing a whole concept of challenges: Energy, water, food, biodiversity, climate change adaptation, exposure to natural hazards, consumption and production patterns, social cohesion and jobs, especially for less privileged …to be continued. More recently, similar lists have described expectations to what Green Infrastructure and Nature-Based Solutions should be able to deliver to upgrade cities and urban areas, in order to create cities that are less vulnerable, more inclusive and resilient and definitely sustainable. And probably they could play an important role in this. If 1 & 1 makes 2, we should by now have found the 'golden key' to win "The Struggle" and we would just need to do our job and implement …We will explore - from the perspectives of cities and a global city network - opportunities and obstacles and the role 'cities' for making 'greening strategies' a successful 'medium' in "Our struggle for Global Sustainability".

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Keynote Speaker
Research-Innovation in NBS implementation

Marta Fernandez, Sarah Bekessy, Mauro Baracco*
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There is an increased interest to bring nature back to cities. Bringing nature to urban centres can deliver a remarkable range of social, environmental and economic benefits, while creating cities that are more resilient to climate change. Creating 'every day nature' in cities presents opportunities to enhance biodiversity whilst increasing land value.

The future of livable cities depends on this new approach to deliver green infrastructures but a change is required in the way nature is planned and deployed.

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SESSION 1
Implications of GI on air quality

ORAL

Keynote Speaker
The effects of green infrastructure on air quality

*David J. Nowak**
USDA Forest Service, Founder of i-Tree

The vegetation associated with green infrastructure affects air quality in numerous ways that ultimately impact the health and well-being of local residents. These effects include altering local meteorology, directly removing air pollutants, emitting various chemicals and particles, and altering local energy use and consequently pollutant emissions from power plants. Not all impacts of green infrastructure are positive in terms of reducing local pollutant concentrations. This presentation will overview how vegetation affects air quality, known impacts of vegetation on air quality and human health, how vegetation type and design can affect local air quality, and means to assess local green infrastructure impacts on air quality. Through a better understanding of how green infrastructure affects local air quality, better green infrastructure designs can implemented to improve air quality and local human health and well-being.

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Impacts of green infrastructures on air quality: an experimental and numerical study in Porto's urban area

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The continuous growth of population living in urban areas worldwide has been increasing the number of critical air pollution episodes alarmingly threatening human health and well-being.

An improved knowledge about the highly complex urban microclimate and consequent air pollution dispersion patterns is therefore of utmost importance to circumvent this emerging problem, either by assisting on the design of efficient resilience measures for highly polluted cities or by allowing a more insightful topological organization of future urban areas.

Resilience measures based on green infrastructures (GI) play an essential role on the urban planning. These infrastructures have the potential to improve air quality, contributing to reduce the impacts of extreme air pollution episodes.

In this paper, we assess the impacts of green infrastructures on the urban microclimate and air quality levels using as case study the Porto's urban area, in the Northern Portugal. In order to evaluate these impacts, we have performed a set of both numerical and physical simulations, using the CFD model VADIS and the wind-tunnel of the University of Aveiro, respectively.

Firstly, the evaluation of the numerical results is performed by comparison with hourly averaged PM10 concentrations measured at an air quality station located within the case study area. Then, the assessment of the impacts of different scenarios applying green infrastructures is performed based on numerical and physical simulations.

The simulation results indicate that air quality strongly depends on the presence of GI. The results clearly show disturbances exerted by GI and their role in improving air quality in the Porto's urban area. Noteworthy, depending on specific conditions, the development of recirculation areas may prevent PM10 dispersion and contribute to the enhancement of PM10 hot-spots. This paper addresses the relevance of the GI integration in urban planning in order to attenuate the impacts on air quality, human comfort and health.

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Vegetation for roadway air pollution mitigation: selection and implementation for Colorado, USA

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Roadway air pollution causes significant negative health effects that impact urban and peri-urban populations disproportionately. Despite reduced per-vehicle emissions, roadway air pollution will likely increase into the foreseeable future due to urbanization and increases in vehicle miles traveled (VMT). Vegetation can provide multiple direct benefits, including air pollution mitigation through physical and micro-climatic effects (i.e., blocking, interception, adsorption, temperature moderation, ion emission). Though initial studies indicate vegetation has potential to efficiently and effectively mitigate near-roadway air pollutants, quantitative estimates of benefits and costs are not yet developed for the South Western U.S., leading to un-accounted-for values and limited implementation.

Our research efforts focus on identifying suitable plants for urban and peri-urban areas in the Southern Rocky Mountain and Great Plains Dry Steppe, as well as the Intermountain Semi-Desert and Desert province. We are concurrently developing strategies for site selection, planting configuration and Best Management Practices (BMPs) to achieve the greatest total benefit/cost of implementation and management. Our goal is to develop quantitative estimates on the effectiveness of near-roadway vegetation to mitigate roadway air pollution and to evaluate selected plant species for optimal design configurations that consider siting, planting, and maintenance attributes to achieve multiple benefits with minimal long-term cost.

The material presented here will focus on species selection and design alternatives to existing Green Infrastructure (GI) designs, with a focus on Colorado's unique bio-physical conditions, and gain insights on GI for roadway air pollution mitigation in the Rocky Mountain West.

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Effect of VOC emissions from vegetation on air quality in Berlin during a heatwave

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The potential for emissions from urban vegetation combined with anthropogenic emissions to produce ozone and particulate matter has long been recognized. This potential increases with rising temperatures and may lead to severe problems with air quality in densely populated areas during heat waves. Here we investigate how heat waves affect emissions of volatile organic compounds from urban/suburban vegetation and corresponding ground-level ozone and particulate matter. In this study we use the Weather Research and Forecasting Model with atmospheric chemistry (WRF-Chem) with emissions of volatile organic compounds from vegetation simulated with MEGAN to quantify some of these feedbacks in Berlin, Germany during the heat wave in 2006. Model simulations indicate that emissions of isoprene from vegetation contribute ~ 12% on average to the ozone formation in summer. During heat wave period this contribution increases to up to 60%. Comparison with isoprene measurements suggest that model greatly underestimates isoprene concentrations for urban parks and forests (~0.6-1.4 ppbv). This discrepancy was partially explained by misclassified vegetation fractions and its LAI. We discuss usefulness of current models to simulate responses of air pollutants to VOC emission from vegetation and suggest necessary improvements.

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Carbon dioxide sequestration capability of the Botanical Garden of Rome: environmental and economic benefits

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The recent decades have seen large increases in the extent of urban and built-up land use. It is predicted that 60% - 90% of the world population will live in cities in 2030. The loss of green areas (urban parks, avenue tree-lines, woods, hedges, private gardens and public green spaces) as a result of the increasing urbanization is a serious threat to the overall biodiversity and calls for considerations of their role, provision and management. Urban green spaces provide ecosystem services, such as offsetting carbon emission, removing air pollution and reducing noise. In particular, green areas act as a sink for atmospheric carbon dioxide (CO2) via photosynthesis and storing excess carbon as biomass. Moreover, they are places for physical recreation which have positive effects on human health. When exposed to green areas people show a greater well-being and physical and psychological benefits. Among the urban green areas, the Botanical Gardens have a key role in biodiversity conservation. Nevertheless, they provide environmental benefits contributing to air amelioration quality. In this context, we analyzed the CO2 sequestration capability of plant collections growing in the Botanical Garden of Rome and their influence on microclimate. The Botanical Garden covers an area of 12 ha in the city centre, between Lungara Street and the Gianicolo hill. The lower area is enriched with tree species, including many palms, while the hill is occupied by the ferns collection, Bamboos, Rose garden, Australian species, Japanese garden, Mediterranean woods and Conifers collection. The results suggest appropriate policy interventions in order to facilitate future urban designs enhancing the environmental and social benefits from green areas.

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Removal of greenhouse gases and pollutants in periurban Mediterranean forest ecosystems described by the Aggregated Interpretation of the Energy balance and water dynamics for Ecosystem services assessment (AIRTREE) model

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The capacity to sequestrate greenhouse gases and pollutants from the atmosphere is one of the ecosystem services which plants provide to citizens in densely populated Mediterranean urban areas. However, the complex interactions between plants and the atmosphere in these regions are still poorly understood. In order to explore the capacity of plants to sequestrate carbon dioxide, ozone, and particles from the atmosphere, we elaborated a multi-layer and dynamic model composed of six different modules: 1. A hydrological component to predict soil water dynamics in response to precipitation, soil textural and hydraulic properties, and evapotranspiration. 2. a canopy model to determine leaf temperature and the radiative flux at different levels from above to the bottom of the canopy. 3. A deposition model based on calculation of different resistances to gas diffusion as a function of atmospheric resistance, leaf boundary layer resistance, and canopy resistances. 4. A photosynthesis model to estimate net photosynthesis and stomatal conductance. 5. A Volatile Organic Compounds (VOC) canopy emission module. 6. Carbon balance computation model based on species-specific allometric relationships to calculate above-ground and below-ground biomass. We validated the model with fluxes of energy, water and trace gases measured using the Eddy Covariance technique in a Mediterranean Holm oak forest located in Castelporziano presidential Estate, a peri-urban forest near the coast of Tyrrhenian sea, 20 km from Rome, Italy. Results show a good agreement between modelled and measured fluxes, highlighting potential application of the model to a broader range of forest ecosystems.

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Modelling the effectiveness of trees on dispersion of vehicular emissions: a real case application to the Marylebone area in central London

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This paper presents a study of the influence of leaf trees (Platanus acerifolia) on NOx and PM2.5 concentrations in the Marylebone neighbourhood of central London, UK. Computational Fluid Dynamics (CFD) simulations are performed with OpenFOAM and validated against the AURN (Automatic Urban and Rural Network) station concentrations. Analyses are performed to clarify the relative contribution of both aerodynamic and deposition effects of trees on pollutant concentrations in the study area. Aerodynamic effects are considered by treating them as a porous media, while deposition effects are considered by adding an enhanced model with an additional sink term, which is novel for such kind of applications.

This work extends our previous study performed in the same study area (Jeanjean et al., submitted to UFUG) where we found that, depending on the wind speed and direction, aerodynamic effects are more important than the deposition effects in trapping pollutants at street level. This is enhanced under wind perpendicular to the street axis, while for parallel winds the aerodynamic effects were instead found to decrease concentrations. Here we further analyse the physical mechanisms for some cases which were found to lead to better and worst air quality. Specifically, we analyse the spatial distribution of concentrations to elucidate the diverse effect of trees over the whole depth of the street canyon by assessing the mean flow and the turbulence intensity. The influence of trees in nearby empty street canyons positioned upwind and downwind is also analysed.

The final aim is to set a CFD-based methodology for such applications and to provide planning suggestions for mitigation strategies and monitoring stations position for a better capturing of high concentration spots.

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Green infrastructures and nature-based solutions to improve regulating ecosystem services in metropolitan cities

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Air pollution due to particulate matter (PM) and tropospheric ozone (O3) poses a significant health risks for European citizens, therefore air quality in urban areas is one of the main challenges for the European Countries. In this regard, the EU recently suggested that the properties of natural ecosystems, and the Ecosystem Services (ES) they provide, might become the focus of specific research and innovation policies in order to find new viable solutions to challenges faced by society. These so-called "nature-based solutions" may exert a positive environmental impact, which could form the basis of sustainable urban planning. Urban and periurban forests, which are integrated within the concept of Green Infrastructure, exert a pivotal role, since they provide important ES, including air quality amelioration through pollutant removal. Our researches quantified the ES of particulate matter (PM10) and Ozone (O3) removal from urban and periurban forests in some metropolitan cities in Italy, and its total monetary value. Different Vegetation Categories and Functional Types were mapped using a remote sensing and GIS approach; by applying a deposition model and a stomatal flux model, the pollution removal of forest ecosystem was evaluated. We estimated, for ten metropolitan cities, an overall pollution abatement of 7150 Mg of PM10 and 30014 Mg of O3 in the year 2003, which was an extremely hot year. The total monetary value of this ES was estimated to be equal to 47 and 297 million USD for PM10 and O3 removal, respectively, thus underlining the crucial role played by nature-based solutions in human well-being in urban areas. These information can be useful to stakeholders for a better development and management of the urban and periurban Green Infrastructure.

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Particle accumulation on branches of urban trees measured with biomagnetic monitoring

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We investigated the role tree branch biomass could play in the atmospheric particle interception service that urban trees provide. In estimates of the impact of urban green on air quality, the particle-collecting surface of tree woody biomass with its own distinct characteristics is largely ignored. In comparison with leaves, woody biomass has a smaller surface area, but has a rougher surface and is exposed to air pollution year-round. In our studies, tree branches were analysed for biomagnetism (saturation isothermal remanent magnetization, SIRM), which is abundantly measured on leaves as proxy for atmospheric particle exposure. In a first campaign on intra-tree variation, London plane trees were sampled in detail in a street canyon, a city park and at a traffic-intensive intersection. Branches of different ages were collected at 20 positions per tree crown, varying in height, azimuth and crown depth. In a second campaign on inter-tree variation, branches were sampled from 55 London plane trees throughout the same city. The branch magnetic signal was attributed mainly to the bark or epidermis of the shoots and increased with each year of exposure, even after five years. This confirms that magnetic particles are deposited on branches, just like on leaves, and that branches go on accumulating magnetic particles for several years. Tree location and height, crown depth and age of the branches significantly influenced the branch SIRM. On projected-area basis, branches showed more than two times higher SIRM than simultaneously exposed leaves. These results imply that woody biomass should not be overlooked in the atmospheric particle-mitigation service of urban trees. Currently, we are investigating the differences in branch magnetism between tree species in a common garden.

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Impact of an urban tree crown on the local distribution of atmospheric dust (PM10) inside an urban street canyon in Antwerp, Belgium

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Besides the direct impact of urban trees on atmospheric particles through dry or wet deposition on their surfaces, tree crowns will influence the aerodynamics of their surroundings, indirectly impacting the local distribution of atmospheric particles. Nevertheless, tree crowns are often represented very rudimentary in three-dimensional air quality models. We, therefore, evaluated the influence of tree crown characteristics on the local ambient PM10 concentration and resulting leaf-deposited PM10, using the three-dimensional computational fluid dynamics (CFD) model ENVI-met® and ground-based LiDAR imaging. The modelled leaf-deposited PM10 mass was compared to gravimetric results within three different particle size fractions (0.2–3, 3–10 and >10 m), obtained from 20 sampling locations within the tree crown. Modelling of the LiDAR-derived tree crown resulted in significantly altered atmospheric PM10 concentrations near the tree crown. Although this model study was limited to a single tree and model configuration, our results demonstrate that improving tree crown characteristics (shape, dimensions and LAD) affects the resulting local PM10 distribution in ENVI-met. An accurate tree crown representation seems, therefore, of great importance when aiming at modelling the local distribution of atmospheric particles.

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Ozone removal by urban and periurban forests in Metropolitan city of Rome

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In urban areas pollutants as tropospheric ozone (O3) exceed the critical level for human health. Urban and peri-urban forests (UF) are integrals to air quality improvement, a regulating Ecosystem Service that enhances the human well-being. O3 removal is connected to vegetation functionality and, in particular, to stomatal conductance (gs), that markedly depends on environmental condition and plant response to stressors. Therefore, a reliable quantification of stomatal O3 removal by UF should take into account the different environmental conditions in the context of Metropolitan areas named heat island, amount of precipitation during the year, pollutants concentrations gradient or green management. To analyze these processes, we selected two experimental sites in the Metropolitan city of Rome: an urban forest (Villa Ada, VA), and peri-urban forest (Castelporziano Presidential Estate, CP). Quercus ilex L. has been chosen as target species, for its wide natural distribution in the Mediterranean Basin, and its widespread use as ornamental tree. Structural and eco-functional field campaigns were carried out to parametrize the process-based forest growth model GOTILWA+. The results highlighted that O3 fluxes were higher in CP during winter, spring and fall owing to higher O3 concentration in CP and due to the detrimental effect that air temperature and Vapour Pressure Deficit have on gs in the urban forest. During the summer period, O3 fluxes in CP were lower than in VA owing to drought. Moreover, simulations performed to test the effect of different climatic condition and irrigation practice underscored that in the urban forest gs, and accordingly O3 removal, were influenced by evaporative demand more than water availability.

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Investigation on the effect of nanoparticles on woody species: interaction, uptake and translocation

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Particulate matter is one of the key global air pollutants. Nowadays the anthropogenic release of nanoparticles (NPs) in the environment poses a potential hazard to human, animal and plant health. Trees can be used as sensitive biomonitors to record local and global environmental change and also to remove air pollution especially in urban ecosystem. We performed an experiment in a greenhouse in order to assess uptake of NPs and follow their transport in the leaves, stem and roots of three different tree species: oak (*Quercus pubescens* Willd.), pine (*Pinus sylvestris* L.) and poplar (*Populus deltoids* Bartram). Soluble NPs of silver (Ag-NPs) were supplied to plants. Oak, pine and poplar were exposed to Ag-NPs at leaf and root level, separately supplied, and they were not subjected to NPs as reference treatment. The main goal of the study was to assess the capacity of woody species to uptake, to transport and accumulate nanoparticles in tissues. The NPs were quantified through ICP-MS analysis and NPs were localized in tissues using scanning and transmission electron microscopy (SEM and TEM). Effects of Ag-NPs on photosynthetic activity and oxidative status, and antimicrobial properties of leaves were also performed to assess tree sensitivity to NPs. Preliminary results showed effect of NPs on plant biometric parameters. A microscopic analysis evidenced deposition of NPs on treated leaves. The same treatment produced a bacterial reduction on leaf surface, in particular for oak and poplar species. The expected results were used to analyse the mechanisms of interaction, transport, allocation and storage of NPs in woody species.

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Are air quality related ecosystem services of European tree species adequately represented in current models?

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Urban development is triggered by the demand for climate change mitigation and adaptation as well as for air pollution reduction strategies. Green infrastructure has been identified as a means to achieving this goal, often with synergistic impacts and high economic efficiency. Algorithms and models have been developed that link the properties of plant functional types, species groups, or single species to their impact on specific ecosystem services. Such models are needed to optimize service provision and minimize disservices. Since plant species diversity is high and different regions perform a different spectrum of species, models that are parameterized on a functional type level are applied to apparently similar species groups without rigorous checking. However, properties affecting air quality such as BVOC emissions are highly species-specific and may largely differ even in phylogenetically closely related species.

A study has been performed that evaluates functions and parameters of the i-Tree model, the most commonly used model for environmental services in urban areas, to determine carbon sequestration, deposition properties, as well as the emission of substances that contribute to ozone and aerosol formation. Specifically, we show the impact of using lumped species parameters instead of local species properties for an extended park area in Munich, Germany. The results show that the use of species-specific parameters is highly important for estimating BVOC emissions but less so if only particle deposition is considered. A species-specific approach is also highly recommended to judge the burden of allergens, although currently this issue has not been explored in any urban study.

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Reducing indoor air pollutants through horticultural biotechnology

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Indoor environmental quality is a growing concern, with populations becoming more urbanised and people spending the majority of their lives indoors. Particulate matter penetrating into the building, volatile organic compounds outgassing from synthetic materials and carbon dioxide from human respiration are major contributors to poor indoor air quality. Whilst a range of physiochemical methods have been developed to remove contaminants from indoor air, all methods have high maintenance costs and none reduce CO2.

We present the latest horticultural biotechnological tools for improving indoor air quality, exploring the history of the technology – from the humble potted plant through to activated botanical biofiltration. Despite many years of study and substantial market demand, a proven formula for indoor air bioremediation for all applications is yet to be developed. Further, we will address the potential future of indoor air bioremediation, with examples of the technology progressing out of the lab and into its application in practice. Additional comments on further research into substrate types, ventilation, and the microbiology of biodegradation processes are addressed, to reveal their ultimate potential.

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How does the amount and composition of PM deposited on Platanus acerifolia leaves change across different cities in Europe?

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Particulate matter (PM) deposited on Platanus acerifolia tree leaves has been sampled in the urban areas of 28 European cities, over 20 countries, with the aim of testing leaf deposited particles as indicator of atmospheric PM concentration and composition. Leaves have been collected close to streets characterised by heavy traffic and within urban parks. Leaf surface density, dimensions, and elemental composition of leaf deposited particles have been compared with leaf magnetic content, and discussed in

connection with air quality data. The PM quantity and size were mainly dependent on the regional background concentration of particles, while the percentage of iron-based particles emerged as a clear marker of traffic-related pollution in most of the sites. This indicates that Platanus acerifolia is highly suitable to be used in atmospheric PM monitoring studies and that morphological and elemental characteristics of leaf deposited particles, joined with the leaf magnetic content, may successfully allow urban PM source apportionment.

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Urban and peri-urban vegetation can improve air quality in Mediterranean areas

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Air pollution is a major environmental problem in most cities across the world.
Current urban development needs to include designs and strategies to minimize atmospheric pollution and improve well-being and human health. Compared to controlling emissions or enhancing dispersion, relatively little attention has been paid to increasing deposition as a pollution abatement strategy. Air pollutant gases and particles are removed from the atmosphere through both wet and dry deposition. In Mediterranean environments, atmospheric deposition is dominated by dry deposition processes. In this sense, urban and peri-urban vegetation, through interception in the canopy surfaces, and via absorption of gases through the stomata, can increase dry deposition, representing a potential strategy for improving urban air quality. In this work, the capacity of urban vegetation to remove air pollutants has been assessed using both experimental measurements and deposition models. Concentrations of the main air pollutant have been measured outside and inside peri-urban forests. The main results show significant reductions of NO2, NH3, HNO3 and O3 inside peri-urban forests in three different locations in Spain. Interestingly, O3 was the only air pollutant whose concentrations were high enough to cause direct effects on peri-urban vegetation. Air pollutant concentration abatement using hedges close to a street has been assessed as well, showing a reduction of black carbon. The influence of trees in air pollution dispersion in street canyons has been analyzed measuring air pollutants at different heights within the canyon. Estimations of air pollutant dry deposition in urban areas have been achieved combining empirical inferential methods with pollutant stomatal exchange models.

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Assessment of particulates abatement by leaf surface of Polyalthia longifolia with a seasonal approach of an urban area

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The green spaces provided within urban infrastructure are the only living windows of biodiversity available for humans in rapid expanding cities. In the present study, we have investigated foliar epidermal surface for widely planted tree species of Annonaceae family; Polyalthia longifolia Sonn. In the Delhi city. The observation of airborne dust settled on plant leaves has witnessed a heavy deposition around petiole region collected from an industrial site and examined for two different seasons. Scanning electron microscope images were examined for the understanding of physical parameters of deposited particulate matter (PM) on plant leaves surface. With the help of quantitative image analyzer software – Image J, the physical features of dust for their number and size distribution pattern in terms of PM10 and PM2.5 were determined. The observation of number density on foliar surface was found 1296 in summer as compared to 1912 for winter season on 0.2mm2. The fine particles were observed maximum in winter with 1775 particles (92 percent) falling under PM0-<2.5 as compared with 577 particles (44 percent) in summer season. The PM2.5-10 in summer season was 47 percent higher than winter season with total contribution of 54 percent in total particles count.The winter months marked with low rate of transpiration, wind speed and intensity of sunlight had observed the presence of aluminum, magnesium, iron and potassium elements in the deposited dust matter signifying the risk of its presence in human ambient air. The foliar surface irrespective of small or large region proves to be continuous natural filter against miniscule sized particles which once enters inside the biological system hampers its functioning and efficiency.

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Livestock NH3 and PM10 emissions and their mitigation by vegetative environmental buffers in periurban areas

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Air quality in urban areas is affected by local emission sources but also by near and long range transport of polluted air masses. In Northern Italy emissions from the densely populated and industrialized areas determine high concentration levels of air pollutants throughout the Po Plain. Emissions from livestock farming, here strongly concentrated, contribute to worsen air quality in this region. Indeed, the cities located in the Po Plain are often affected by emissions of animal farming which enhance health risks. Livestock represents a relevant contributor to PM10 emissions (ca.10% of the total primary PM10 emissions) and the major source of NH3 (95%).

Vegetative environmental buffers (VEB), e.g. shelterbelts, are vegetation systems, that use trees and shrubs arranged in rows or groups, reducing wind speed and, consequently, modifying environmental conditions. Moreover, trees and shrubs provide visual diversity within agricultural landscapes and improve biodiversity contributing to the recreation potential of many farms. A relevant "ecosystem service" provided by VEBs is to intercept pollutants released by animals and livestock related structures. These pollutants may affect air quality in urban areas due to transport phenomena.

In this study we analyze the role of VEBs to remove NH3 and PM10 emitted by animal farming comparing emissions and removals at different scales (a farm and a rural municipality). Results suggest that VEBs may represent a valuable tool to remove a significant amount of the pollutants, avoiding their transport and diffusion to other rural areas and near located cities. Data collected underline the potential role of VEBs in air quality management in areas characterized by a relevant industrial livestock production.

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Activities during cost action fp1204 related to air phytoremediation performed in Warsaw, Poland and Stavanger, Norway

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Transportation, industry and household emit various pollutants to the air including particulate matters (PM) - nowadays number one harmful, air pollutant. PM toxicity is magnified when they carry heavy metals (HM), polycyclic aromatic hydrocarbons (PAH) and environmentally persistent free radicals (EPFR). Air as very mobile component of environment is most challenging to be cleaned. If pollutants are emitted to the atmosphere, the only option to remove them in controlled by man manner is phytoremediation - environmental biotechnology in which plants are employed to capture impurities. Plants as a sessile organisms are relatively high tolerant to pollution, which together with large surface, few times larger than surface occupied for their growth became useful for phytoremediation. Working hypothesis of our study was: as for many other traits we expect that there are significant genotypic inter- and intra-species differences in plant usefulness for phytoremediation. Over 60 trees, shrubs and grass species, recommended for urban areas, were evaluated in our Lab for ability of PM accumulation in 3-4 years studies.

Mass of PM and epicuticular waxes were determined gravimetrically. The PM was determined in two categories; surface PM (sPM) and phytostabilised in wax (wPM) and in three size fractions (10–100, 2.5–10, and 0.2–2.5 μm) according to method elaborated in our Lab and described by (Sæbo et al 2013, Popek et al 2013) .

Great differences exist between examined species in their ability to accumulate PM (up to 10 times). Out of total slightly more than half of PM was sPM (washed with water so this part is probably also easy to be removed by rain and wind). Species of hairy and rough leaves accumulate more coarse PM but those having only wax accumulate more PM of fine fraction and this part as more tightly bound to leaves is for longer time phytostistabilised. A number of species of trees growing in the more polluted places in Warsaw accumulate on 1 cm2 of the leaf more than 40 μg of PM which is the threshold amount of pollutants for 1 cubic meter of polluted air in the European Union.

Still, we are unsatisfied with the performance of the accumulation of air pollutant by plants. Current research is focused on understanding and using microbiome plant species that are already known as a good phytoremediant. In the case of air phytoremediation we are interested in both phyllobacteria and endobacteria (Veyens et al 2015).

Although phytoremediation is a relatively young scientific discipline but is growing very rapidly, and is likely to play an important role in protecting our health and improving human well-being

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Atmospheric pollution and urban trees: an integrated approach for green space analysis and management in the industrial city of Terni

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Particulate Matter (PM) is widely recognized as one of the most harmful pollutants for human health and trees have been shown to represent an effective tool in PM removal in urban environments. Air pollution mitigation through urban vegetation can be a useful instrument for cities administration. In the present study the combination of different investigation approaches was applied in order to describe the actual and the potential air pollution mitigation by trees in the industrial city of Terni in central Italy. Qualitative and quantitative analysis of PM deposited on vegetation was implemented directly on urban tree leaves of holm oak (Quercus ilex). Different particles both for dimensions and chemical composition and different amounts were related to specific polluting sources. Field studies were then integrated by Model analysis: air pollution dispersion was modeled (TAPM, The Air Pollution Model, Australia) and trees potential capability in PM removal was observed (i-Tree model, U.S.). Finally, through the integration of GIS approach, modeling and in collaboration with local municipality a priority planting plan was designed.

The integration among scientific research, urban planning and local administration needs are fundamental for a new approach of urban environmental challenges, and to design functional green infrastructure.

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A multi-scale spatially-explicit method to assess the capacity of air pollution removal by urban forests in the city of Florence, Italy

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Urban forest (UF) provides a range of ecosystem services (ES) important for human well-being. Relevant ES delivered by UF include urban temperature regulation, runoff mitigation, noise reduction, recreation, and air purification. In this study we investigated the potential of air pollution removal by UF in the city of Florence (Italy). Two main air pollutants were considered: particulate matter (PM10) and tropospheric ozone (O3). Our aims were to provide a methodological framework for mapping the ES air pollutant removal by UF, and to assess the percent removal of air pollutant.

The distribution of UF was mapped by remote sensing data and classified into seven forest categories. We estimated the Leaf Area Index (LAI) spatially using a regression model between on-field LAI survey and Airborne Laser Scanning data that resulted in good linear agreement with estimates from ground-based measurements (R2 = 0.88 and RMSE% = 11%). We retrieved pollution concentration measured in 2013 in urban monitoring stations to estimate pollutant removal potential. Annual O3 and PM10 removal accounted for 77.9 tons and 171.3 tons, respectively. O3 and PM10 removal per unit area by evergreen broadleaves (0.16 and 0.27 tons/ha), conifers (0.11 and 0.28 tons/ha), and mixed evergreen species (0.16 and 0.32 tons/ha) was higher than in deciduous broadleaves stands (0.04 and 0.10 tons/ha). However, deciduous forest had the largest total removal due to its high percent tree cover within the city. Our study confirm that UF has an important role in air purification in Mediterranean cities, as they can remove hourly up to 5 and 13% of O3 and PM10, respectively.

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SESSION 1
Implications of GI on air quality

POSTER

Trace gases exchange in an urban park in Naples

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Urban forests and parks are living systems integrated in highly anthropic areas, where they establish close interactions with the surrounding environment by means of physical, chemical and biological processes. Thanks to those interactions, urban forests provide many environmental services at both global and local scale. The main service at global scale is the sequestration (sink) of CO_2 and at the same time an indirect avoidance of CO_2 emissions due to cooling effect and the consequent decrease of energy consumption should be considered. While, at local scale, urban forests provide services such as the regulation of microclimatic conditions, and especially the absorption of chemically and radiatively-active trace gases and thus the effect on local air quality and the the improvement of the urban environment human health and well-being. Beyond the main greenhouse gases (CO_2, H_2O and CH_4), in urban areas a relevant role is played by the photochemical pollution mainly constituted by O_3 and particulate matters (PM). Despite their importance, experimental sites monitoring trace gases fluxes in urban forest ecosystems and parks are still scarce and the estimation of air pollutants removal capacity by urban forests is mainly carried out by means of models rarely compared with field measurements. Here we present experimental station of Real Bosco di Capodimonte, located within the city of Naples. The vegetation is mainly composed by Quercus ilex with some patches of Pinus pinea and meadows. The site is equipped with state of the art instruments to measure concentrations and exchanges of CO_2, H_2O, CH_4, O_3, PM, VOC_s and NO_x by the eddy covariance technique. The eddy covariance (EC) technique is a reliable method to assess exchange of masses (gases, PMs) between biosphere and atmosphere, and is widely used to measure CO_2 and H_2O exchange above several surfaces such as terrestrial and aquatic ecosystems, urban areas and even landfills

The preliminary results showed here suggest that the EC technique can be applied at the "Bosco di Capodimonte" site, offering a unique opportunity to understand the role of urban vegetation on the dynamics a number of trace gases and the processes regulating their fluxes and interactions. This includes the role of BVOC for O_3 absorption and formation, the interaction between BVOC emission and CH_4 concentration, and finally how all the air pollutants will influence CO_2 sequestration. Moreover, the experimental site will be a perfect case study to test and improve the existing models for quantification of pollutants absorption by vegetation. We believe that this case study will increase awareness of the importance of such kind of stations both from the scientific and the practical point of view and will promote the concept of a network of urban park stations in the future.

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The green cover of city ecosystem-green roof

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The adverse developments such as the adverse effects of urbanization on natural values increasing day by day and the environmental pollution due to urbanization increasing the effects on human health push all interested groups forming the city to multi-dimensional thinking and questioning on the concept of "ecological city renewal and livable healthy city". Cities are ecosystems that contain natural structures and systems, as well as the interaction of cultural and natural structures, as well as being intensified areas of anthropogenic activity. There is a relationship between urban tissue organizations in urban areas and infrastructure systems. This relationship has become even more important, especially with the reduction of green areas in urban areas and the preference of impervious surface coatings.

With urbanization there is an accurate relationship between population growth and impervious surfaces. The amount of impermeable surface (the amount of area covered with impermeable surface, the area of roofs, concrete surfaces, etc.) is a key environmental indicator in the impact of urban land use. In recent years, concepts such as Integrated Urban Water Planning, Water Sensitive Urban Design, Urban Water Efficiency Planning and Rainwater Management Approaches have proposed scientific approaches for solution.

This report will focus on the climatic and ecological effects and design and examples of the Green Ripples used to direct, slow down and refine rainwater as Rain Water Management Systems.

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Particulate matter deposition on urban green: an indicator of habitat quality in cities

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Particulate matter (PM) consists of a panoply of fine respirable particles suspended in the air. Throughout Europe, atmospheric PM is monitored continuously through a network of monitoring stations, mostly providing gravimetric-based PM concentrations, while the chemical composition is usually neglected. Moreover, the spatial resolution of these monitoring stations is too low to properly monitor the high spatial variability in atmospheric PM exposure in cities. Urban green can play herein an important role as pollution bio-indicator, as it provides a natural surface for deposition and immobilization of small airborne particles. The use of plant leaves as passive urban PM collectors submitted to magnetic analyses, provides a robust and cost-effective PM monitoring, which can be used to rapidly detect high-polluted areas.

In this study, magnetic- and particle-based techniques were used to investigate PM deposition on ivy leaves collected from different land use classes (forest, rural, roadside, industrial, train) in the city of Antwerp, Belgium. Leaf magnetic measurements were done via saturation isothermal remanent magnetization (leaf SIRM), while ca. 40,000 leaf-deposited particles were analyzed through SEM/EDX to estimate the elemental chemical composition. Leaf SIRM values were obtained in the following order: train > industrial > roadside > rural > forest, and showed to be related with Fe, Zn, Pb, Mn, and Cd, particulate content. Although further research is still necessary, the relation between leaf SIRM and the deposited metal content suggested that these particles are mostly source-dependent. The results showed that ivy leaves can be used as a monitor tool for urban PM pollution, allowing the distinction of land use classes with different urban habitat quality.

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Analysis of relations between rare earth elements accumulation in Taraxacum officinale L. and land use in the urban area

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Rare earth elements are becoming one of the most important elements, due to their occurrence in common IT devices and cars, and in turn their increasing concentration in the environment, including soil, water, air and living organisms. There is still unknown the effect of these elements to human health and ecosystems, however higher concern should be paid for their increasing concentration and potential relations to human activities, such as urban spatial planning.

The aim of presented study was to evaluate the accumulation of rare earth elements (REE) content in leaves of Taraxacum officinale L. and spatial analysis of obtain results in regard to land use of Poznan city area (Poland).

The city area was divided into 4 km2 squares and the plant leaf samples were collected from each squares. The REEs include two groups Light Rare Earth Elements (LREE) and Heavy Rare Earth Elements (HREE). The following LREEs were here analysed: cerium (Ce), gadolinium (Gd), lanthanum (La), neodymium (Nd), samarium (Sm), while HREEs include terbium (Tb), thulium (Tm), yttrium (Y), ytterbium (Yb), erbium (Er). All elements were analysed by inductively coupled plasma optical emission spectrometry followed by microwave-assisted sample digestion by concentrated nitric acid. For graphical data presentation, GIS tools were used.

Due to specific features of analysed elements and their occurrence in many mobile devices the difficulties were found to point the direct relations between land use and their accumulation in plants. It seems that their mobility in the environment and increasing number of common use devices caused wide range of occurrence in the urban area, including green infrastructure.

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The effects of trees on flow and pollutant dispersion in urban areas: a short review of experiments and microscale simulations

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The urbanization extensively modifies the climate at local, regional and global scales and causes concerns about levels of air pollution in cities. The spatial distribution of pollutants is determined by several factors, such as building geometry and environment topography, wind speed, wind direction, atmospheric stability, together with the presence of obstacles such as vegetation, low barriers and parked cars.

Experiments and modelling simulations have shown that urban vegetation induces two different effects, i.e. passive mitigation for air pollution (deposition effect) and changes on the street flow behaviour even with adverse effects due to the reduction of ventilation in the streets (aerodynamics effect). Recent reviews have pointed out that very little has been done attempting to comprehensively evaluate the aerodynamics and deposition effects of trees in real scenarios (Gallagher et al., 2015, Atm. Env. 120; Janhäll, 2015, Atm. Env. 105).

In this paper we review the latest results obtained by us and other authors using Computational Fluid Dynamics complemented by experimental data from recent field and laboratory campaigns studying the effects linking vegetation to air quality. It is worth noting that the aerodynamics and deposition effects have been separately investigated, and only few recent studies bring them together to enable an appreciation of their relative influences and how they interact. Latest urban air quality application studies are thus critically re-visited to provide input on the design of urban vegetation related to air quality and on the development of tree parameterizations in mesoscale models.

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Identifying ozone impacts on greening woody species by microscopy

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Ozone concentrations in urban forests and periurban areas can be relatively high, inducing leaf visible injury in sensitive species. Assessment of the impacts of this pollutant may however be complex as other biotic and biotic factors can produce similar symptoms. Characterization of these symptoms under controlled conditions at anatomical level can provide support for a correct identification of ozone symptoms in the field. Sixteen woody species commonly used in urban greening were exposed to elevated ozone in Open Top Chambers in order to characterize their anatomical responses. The species were: Acer campestre, Acer pseudoplatanus, Ailanthus altissima, Betula alba, Fraxinus excelsior, Pinus halepensis, Pistacia terebinthus, Prunus spinosa, Quercus ilex, Quercus suber, Robinia pseudoacacia, Sambucus nigra, Sorbus aria, Sorbus latifolia, Ulmus pumila, and Viburnum lantana. Palisade parenchyma cells were in general the most affected part of the mesophyll. In some species, the middle lamella of the cell wall was degraded and small pectinaceous drops were produced. Cell walls were progressively altered and, in some species, callose was accumulated between the membrane and cell wall. Tannins were accumulated in the vacuoles or became coagulated. Finally, cells collapsed, leading to an increase of intercellular spaces. In general, upper and lower epidermises were less affected. In some cases, the guard cells of stomata accumulated large starch grains, which suggest an impairment of its function. In the vascular bundles, xylem was usually unaffected, but phloem cells sometimes experienced changes in shape and callose deposition increases in the sieve tubes which may affect sucrose transport. Patterns of response for the different species are commented.

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Fluxes of greenhouse gases and biogenic volatile organic compounds in a peri-urban Holm oak forest

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Among the ecosystem services that Mediterranean forests can offer, the regulation of air quality and climate are of primary importance. Vegetation sequestrate CO2 from the atmosphere and phytoremediate the air by removing pollutants like Ozone (O3) and particulate matter (PM). Furthermore, plants emit volatile substances (BVOCs) that interact with GHGs and with air chemistry, in particular under stress condition. Nevertheless, Mediterranean forest are among the most threatened ecosystems on Earth by climate changes. The resulting environmental stress coupled to the interaction with these pollutants can affect forest carbon balance. In order to fully explore the plant-atmosphere interactions, eddy covariance technique was used to measure bi-directional exchanges of greenhouse gases (carbon dioxide, water vapour, ozone), BVOCs and PM in a Mediterranean Holm oak forest located in Castelporziano presidential Estate, a peri-urban forest near the coast of Tyrrhenian Sea, 25 km from Rome downtown, Italy. The concentration gradient along the canopy profile of Volatile Organic Compounds (VOCs) was measured during intensive field campaigns using a proton transfer reaction - mass spectrometer (PTR-MS). Overall, the Holm Oak canopy exhibited a bi-directional dynamic of fluxes. Our results showed that the Holm Oak forest is a net sink of CO2 and that the sink strength is related to inter-annual variations in water availability.

The ecosystem is a source of BVOCs, largely represented by reactive monoterpenes, mostly recorded in the central hours of the day in response to elevated light intensities and temperatures. The forest is a sink for O3, removed by plants mainly through stomatal uptake. Finally, the site is a sink for particulate matter, transported all day long from different sources. Our study contributes to better understanding the complex interactions between biosphere and atmosphere in a densely populated Mediterranean area where pollution and climate changes represent a major threat to terrestrial ecosystems.

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Leaf-deposition of atmospheric dust as a biomonitoring tool for the urban distribution of atmospheric pollution: a novel ecosystem service?

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In contemporary cities, the appearance of vegetation exerts many so-called ecosystem services. Next to carbon sequestration, micro-climate regulation, noise reduction, rainwater drainage, psychological and recreational values, a significant amount of research has focussed on the air pollution mitigation potential of urban vegetation. But what if we would be able to use the particle-capture efficiency of urban tree leaves as a passive means to monitor atmospheric pollution? My PhD research evaluated the feasibility of biomagnetic monitoring by means of Saturation Isothermal Remanent Magnetisation (SIRM) of leaf-deposited particles from an air quality monitoring and modelling perspective, at both spatial and temporal resolutions. We evaluated the applicability of the biomagnetic monitoring approach, both in terms of spatial and temporal monitoring scale in Antwerp (BE) and Ghent (BE) (Hofman et al., 2014d, 2013), characterised the relationship between the biomagnetic signal and the gravimetric load of leaf-deposited particles within 0.2-3, 3-10 and >10 μm particle size fractions (Hofman et al., 2014b, 2014c) and evaluated the applicability of biomagnetic monitoring for validation purposes of air quality models (ENVI-met® and IFDM-OSPM modelling chain) at different spatial scales (Hofman and Samson, 2014; Hofman et al., 2014a). Especially in heterogeneous urban environments, where traditional telemetric monitoring networks are limited in terms of spatial resolution, biomagnetic monitoring of urban trees might serve as a novel ecosystem service, enabling the collection of high-resolution air quality information.

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Can urban forestry really reduce air pollution? A field study on a city scale

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It is widely understood that the activities of plants can lead to reductions in ambient air pollutants; however limited studies provide empirical data, as opposed to model estimates, of their ability to do so. The work presented here represents a field study assessing urban air pollution across Sydney, Australia and examined whether higher concentrations of urban forestry were associated with quantifiable effects on ambient air pollutant levels. The findings indicate that whilst meteorological factors and vehicular traffic did have an influence in determining particulate matter concentrations; greenspace, and especially the density of nearby canopy coverage to the sample sites, were integral influences on reduced ambient particulate matter concentrations. However, if the greenspace was composed of grass, no improvements to air quality were observed, compared to areas with a high-density tree canopy. The work was extended to studying naturally ventilated buildings, as they tend to have parity indoor-to-outdoor pollutant ratios in most instances. Consequently, naturally ventilated buildings air pollutant concentrations did resemble that of the incoming outdoor air supply, thus, if these buildings are located in areas of high urban forestry density; urban forestry is likely to influence the composition of air pollutants within these buildings. The results combined, demonstrate that urban forestry does influence air pollutant exposure substantially, however its type and composition will determine its effectiveness.

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Active green wall technology for the phytoremediation of indoor air pollutants

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There is a growing requirement to find measures to control and prevent the health risks associated with poor urban air quality; with an equally important requirement to find energy There is a growing requirement to find measures to control and prevent the health risks associated with poor urban air quality; with an equally important requirement to find energy efficient means to do so.

Whilst it is widely accepted that indoor plants are capable of removing most air contaminants from indoor environments, however practical numbers of traditional potted plants will not have the capacity to adequately control some forms for air pollution, notably particulate matter and carbon dioxide.

To address this problem, we have developed an active, modular green wall system; capable of biofiltering polluted indoor air. Testing of this system indicated that the active green wall system was capable of rapidly removing all fractions of particulate matter and volatile organic compounds. Further investigation showed ambient CO2 draw down could be achieved with light levels greater than 2190 lux (50 μmol m-2 s-1). Test room simulations demonstrated that with appropriate plant selection, a 5 m2 green wall could balance the respiratory emissions of a full-time occupant, and reduce air conditioning costs substantially. Potential fungal and bacterial emissions from the green walls were also tested, with no significant health risks or increased bioaerosols detected.

Even at an early stage of development, active greenwall technology thus has considerable potential to remediate pollutants from indoor air, along with reducing the operational expense of building ventilation systems.

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The effect of polycyclic aromatic hydrocarbons contamination in the cities on the retention capability of tree crowns

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Interception defined as the amount of precipitation retained in tree crowns, is one of the main component of water balance of the forest and urban ecosystems. Even small changes in hydrophilicity of tree crowns can induce huge ecological consequences in urbanized catchments. PM10, PM2.5 and tarry substances rich in polycyclic aromatic hydrocarbons, which are retained on leaves cause changes for water retained by tree.

The goal of this study was to analyze the relationship between rainfall interception of small-leaved lime, common poplar and distance from the city center from April through November.

We implemented a series of studies under laboratory conditions which included spraying of tree twigs collected at three distances from the center (Krakow, southern Poland) and from outside the city. The background for the interception values were the results acquired from selected polycyclic aromatic hydrocarbons (PAHs) content determined in leaves from studies using HPLC, and images of leaves surface acquired via Scanning Electron Microscope (SEM).

Based on the results obtained, we concluded that there were significant differences in interception between areas for each month. Under the effect of impurities, hydrophilicity of leaves was lower from April to July, and in the second half of the growing season its value was increased in comparison to uncontaminated areas. Both the values of interception losses seasonal trends of the curves were changed. Determination of the optimal combination of trees considering hydrological characteristics may be a new challenge for the management of urban green space. Based on statistical analysis, it was found that the effect of pollution on the interception cannot be ignored in building forecasts and models describing ecosystem.

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Urban vegetation as a mitigator of air pollution exposure – a case study in Gothenburg, Sweden

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Air pollution levels (NO2, PAHs, O3) were investigated, before (BLE) and after (ALE) leaf emergence, in the urban landscape of the City of Gothenburg. The aims were to study 1) the variation in pollution levels between different green areas in the urban landscape, 2) the direct effect of urban vegetation on air pollution levels by enhanced deposition, and 3) the improvement of urban air quality as the combined result of the distance to traffic emissions and deposition in urban parks. The results showed that O3 varied little over the urban landscape but was lower in more NO2 polluted sites and periods. NO2 varied strongly and was higher in situations strongly influenced by traffic. Four PAH variables were included: total PAH, total particle-bound PAH, the quantitatively important gaseous phenanthrene and the highly toxic particle-bound benso(a)pyrene. The variation of PAHs was similar to NO2, but for certain PAHs the difference between highly and less polluted sites was even larger than for NO2. Inside vegetation, NO2 and particulate PAH levels were lower than outside at a certain distance form a busy traffic route. This effect was significantly larger ALE compared to BLE for NO2, indicating green leaf area to be highly significant factor. At one studied site, for particulate PAHs, the effect was similar between both periods indicating tree bark and branches also could to be an important factor in reducing air pollution. Parks represented considerably cleaner local environments (park effect), which is likely to be a consequence of both dilution (distance effect) and deposition. Our results are evidence that urban green spaces are beneficial for urban environmental quality, which is important to consider in urban planning.

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Green walls for sustainable buildings and cities: aerodynamic characterisation of vegetation

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Air pollution due to particulate matter (PM) is the number one cause of premature mortality in urban environments (WHO 2014). It is known that local peaks in atmospheric PM concentration can be reduced by urban green via deposition on the leaves. Green walls are particularly interesting in this concept because, in contrast to e.g. urban trees, they do not obstruct ventilation in street canyons, they can be installed at locations where space is limited and they allow much more flexibility in terms of thoughtful planning. Furthermore they provide additional ecosystem services, such as urban heath island effect mitigation, increase in biodiversity (including pollination facilitation), increase in life quality of citizens, etc.

The primary objective of this study is to acquire a clear and total view on how and to what extend green walls capture PM (and thus contribute to cleaner air).

For estimation of PM removal efficiency it is important to know how urban airflows interact with vegetation, and what characteristics are determinative for PM deposition. To address these questions, firstly a wind tunnel experiment was conducted in order to measure the pressure drop caused by typical green wall vegetation in an air flow. Subsequently the experiments were simulated with COMSOL Multiphysics.

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Dust and Heavy metal pollution and health risk assessment in urban areas using tree leaves

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Air pollution by dust heavy metals were studied using tree leaves as natural filters in Armenia's two cities located in different landscape zones, with different histories of origination, development, and pollution sources. The contents of Ni, Cr, Pb, Mo, Cd, Zn, Cu were investigated in leaf dust of the most widely spread tree species: Ulmus laevis Pall, Ulmus parvifolia, Juglans regia, Platanus orientalis, Syringa vulgaris, Populus alba, and Morus alba, Acer negundo, Robinia pseudoacacia. Heavy metal pollution levels were evaluated by calculating geo-accumulation (Igeo), summary pollution (Zc) and Summary Concentration Indices (SCI). Health risk was assessed using the US EPA human health risk assessment model. According to results, Yerevan dust is characterized by higher indices both qualitative and quantitative. Most of the samples collected in Yerevan show a higher dust load, whereas low dust load is characteristic of samples taken from Gyumri. The obtained heavy metal pollution assessment data have indicated that the background and MAC -exceeding values of the studied elements are higher in Yerevan as compared with Gyumri. Priority pollutants to Yerevan are Mo and Cd, to Gyumri- Cr and Pb. According to Zc, pollution level in Yerevan ranges from low to very high, whereas the Gyumri samples are characterized by a low level of pollution. Health risk assessment data have indicated that there is no noncarcinogenic risk (HI>1) in Gyumri, while in Yerevan risk to children is determined by Mo and Co, to adults- by Mo alone. According to carcinogenic risk assessment data, both in Gyumri and Yerevan there is carcinogenic risk determined by Cr which however is at a low level.

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A comparison of ozone sensitivity in urban tree species grown under free-air ozone exposure

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Tropospheric ozone (O3) concentrations have increased by 60–100% in the Northern Hemisphere since the 19th century. Ozone is taken up into the plants via stomata. As a result, the phytotoxic nature of ozone can impair growth of trees. The classification of the sensitivity of tree species to O3 could be useful information to estimate the potential impacts of O3 on the trees for urban greening. In this presentation, we will introduce our recent experimental results about the physiological traits (i.e., photosynthesis) and biomass growth in several tree species grown under a novel free-air O3 exposure experiment. We will thus discuss the sensitivity of tree species to O3, and will contribute to develop our knowledge about the impacts of O3 on Urban forest.

In the ozone FACE (Free-Air Controlled Exposure) experiments at Sesto Fiorentino, CNR campus, in Italy (43°49'N, 11°12'E), we investigated the response to ozone about common European oaks (Quercus ilex, Q. robur, and Q. pubescens) in 2015, poplar clone (Oxford, Populus maximoviczii Henry × berolinensis Dippel), and fast grown tropical tree species (Croton floribundus and Schinus terebinthifolius) in 2016. Three levels of O3 concentration was applied (Ambient (AA), AA x 1.2, AA x 1.4 in 2015; AA, AA x 1.5, AA x 2.0 in 2016).

On the basis of the experimental results, we found the species-specific differences of the sensitivity to O3. Q. ilex did not show any clear effects of O3 on the photosynthetic rate and biomass growth. On the other hand, O3 affected the photosynthetic traits in Q. robur and Oxford poplar clone. Also fine-roots biomass of Q. robur was limited under elevated O3. Ozone interestingly tend to decrease diameter growth of S. terebinthifolius even though we did not find the O3-induced decline of leaf-level

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Biomonitoring of Urban Air Quality: the Potential of Hyperspectral Reflectance Measurements

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Air pollution in cities pose serious health risks. As conventional air pollution monitoring stations only provide coarse-scale spatial information on exposure to pollutants, alternative monitoring techniques with high spatial resolution are necessary. A possibility is biomonitoring of local urban green. Pollution can induce stress in vegetation altering the morphological and physiological characteristics of the leaves. These changes are likely to be detected in leaf radiative transfer measurements. In this study the potential of hyperspectral leaf reflectance and chlorophyll fluorescence as an indicator for urban air quality is explored.

Measurements were performed in Antwerp (Belgium) and in Valencia (Spain). To obtain information about the spatial variation in urban air quality Saturation Isothermal Remanent Magnetization (SIRM), a magnetic leaf biomonitoring technique, was used on 155 plane trees (Platanus x. acerifolia). Based on these measurements, 56 trees were selected to measure physiological and reflectance based leaf characteristics. These trees were spatially distributed over different pollution classes. Passive hyperspectral measurements were performed using the FluoWat leaf clip coupled to an ASD spectroradiometer. Chlorophyll fluorescence was actively measured using fluorescence images, the Plant Efficiency Analyzer (PEA) and Pulse Amplitude Modulation (PAM).

The first results illustrate that hyperspectral reflectance and chlorophyll fluorescence can be used to distinguish air quality variation on a local scale. When each tree becomes a monitoring station, air quality can be mapped in detail with high spatial resolution.

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Use of the European Photo-Reactor (EUPHORE) for testing the depolluting capacity of representative combinations of urban vegetation

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Simulation chambers are important tools to mimic the chemical atmospheric processes occurring in the atmosphere. The European Photo-Reactor EUPHORE is one of the major outdoor atmospheric simulation chambers in the world (two 200 m3 chambers) allowing the reproduction of the behavior of target compounds under quasi-real conditions. It is equipped with a suit variety of analytical instruments in order to analyze Volatile organic compounds, ozone, NO, NO2, SO2, PAN, organic nitrates, hydroperoxides, radicals, aerosols and organic acids. Besides, for in-situ measurements, highly sensitive and selective techniques such as LP-FTIR and LP-UV/VIS DOAS spectroscopy are available. For the sensitive analysis of product formation, HONO-LOPAP monitor, PTRMS, GC-MS and GC-MS/MS systems can be employed for sampling the trace gas components directly from the gas phase. To characterize aerosol formation EUPHORE is equipped with two SMPS systems and a continuous-operating microbalance (TEOM) providing particle numbers and mass concentration. Other off-line techniques, such HPLC and LC-MS or GC-MS for the analysis of different range of compounds, both in gas and particle phase, are also available.

Thanks to the large volume of the chambers, illuminated with sunlight, it is possible to introduce different combinations of urban vegetation inside and to study plants emission (BVOCs) interactions in a polluted urban environment (NOx, O3…), including the potential formation of secondary pollutants (e.g. particles, aldehydes, etc). It will also be possible to estimate the plant pollutant removal capacity. After some promising tests, planned experiments are expected to provide new insights into the suitability of different plant combinations for polluted cities.

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SESSION 2

GI for water and soil management and remediation

ORAL

Keynote Speaker
Creating deep forms in urban nature

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Urban nature includes designed ecosystems that can be composed of what John Tillman Lyle () termed "deep forms" in which human beings and their natural habitats are reunited at both regional and experiential scales. Urban nature should be considered a part of humanity's creative adaptation to its urban environments, and should be a key factor in addressing contemporary challenges from pollution, flooding, and habitat destruction to the loss of cultural identity, social inequality, and declining public health. In other words, urban nature must be able to provide multiple ecosystem services, including provisioning, environmental remediation, and life support, as well as cultural services such as education, recreation and aesthetic experience. The holistic services that urban nature can provide are the glue that will be able to bind humanity and nature together.

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PB distribution within vertical and horizontal mixed vegetation layers growing in a lead contaminated site

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Until the late ’70, the lead was the main component of the enamels used to color the ceramic tiles; the presence of this compound in the ceramic sludge has been a source of environmental pollution as consequence of the spread of these dangerous waste in the soil, without any containment measures. These contaminated soils, are often found close to industrial sites, frequently located in the peri-urban areas, thus representing a considerable hazard to human and ecosystem health. In this study, we applied the phytoscreening technique to investigate the spatial distribution of Pb soil pollution, analyzing the vegetation (Phragmites australis, Salix spp. and Sambucus nigra) growing along the riverbank of Fosso Categge in Gualdo Tadino (PG-Italy). The analysis showed a different lead accumulation among the species and plant tissues (vertical layers). Salix trees were not affected by the Pb contamination, suggesting a disposal of the sludge in the upper layer of the soil when the trees were already present. Differently, in the Sambucus we found high concentrations of lead in all the plant tissues and in the fruits, with potential dangerous phenomenon of biomagnification. The Phragmites accumulated large amounts of Pb in the rhizomes in response to exposure to contamination. Given the homogeneous distribution of this species in the site, we used their rhizomes to realise the map of the lead contamination (horizontal layer). Using the phytoscreening technique, we obtained at the same time information about the history of the contamination, the associated risks and the distribution. Finally, we speculated about the role of natural recolonizing plants on the reduction of the contamination diffusion, considering their well know role on decreasing the soil erosion and water runoff.

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Hydrological and plant functionality of the rain gardens of the Agripolis Campus (north-east Italy)

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Since Spring 2011 a roof of a building of the Agripolis Campus of the University of Padova (Italy) has been chosen as the drainage area for two rain gardens having a circular shape area of about 10% and 20% respectively of the drainage area. To improve the soil infiltration capacity, up to the depth of 1 m the topsoil was removed and filled with a mix of 50% sand, 25% organic compost and 25% of the existing topsoil. To test the adaptability at different soil water condition, some herbaceous perennials were selected and planted. The runoff discharged from the building roof was diverted in a tank equipped with a V-notch weir for the water runoff measurement. A system of TRD sensors was installed in the soil at different depths. To evaluate the capability of each rain garden to manage stormwater runoff a simplified water balance was done. Actual evapotranspiration was estimated using the WUCOLS method.

Due to irregular operation of the pump in the sump that collected runoff from three gutters of the roof, from Autumn 2012 runoff volumes were collected only from a pitch of the roof with two gutters and directed only in the small rain garden become equal to 15% of the new roof drainage area. So, we had the possibility to test three rain gardens with different percentage of the roof drainage area: 10, 15 and 20%, even if in different periods.

Only during few rainfall events the input water volumes caused overflow. Preliminary results showed a high ability to manage stormwater runoff and almost total roof runoff volumes were infiltrated into the rain gardens, also more than 100%, if we consider only the roof runoff volumes. As regard the plants, results show that the plant growth of the species is affected by the position from the highest humid condition in centre to the driest condition in the perimeter, except for *Hemerocallis hybrida* that showed great adaptability in all position.

Aster, Hemerocallis, Iris, Molinia and Rudbeckia have shown a good adaptation, with high aesthetic results.

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A holistic methodological framework for estimating water retention potential in urban forests

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Urban trees and forested areas have a great water retention potential since they are enhancing evapotranspiration and water infiltration into the soil as well as regulating the amount of throughfall reaching the ground.

This study provides a holistic methodological framework for estimating natural water retention potential of urban forests to assist in the managing and planning of urban forests for hydrological benefits. We propose and test a combination of indicators, related to canopy interception, topsoil water infiltration and soil water holding capacity in urban forests which differ in stand structure and soil properties. We standardized the obtained values on a relative scale: from 0 – no relevant potential; to 100 – maximum possible potential of urban forests under study for water retention.

The study occurred over a six-year period in an urban transect from the mixed forest in the city center towards a riparian pine forest and a floodplain hardwood forest. Canopy interception was calculated as a difference between measured open field precipitation and net precipitation (sum of throughfall and stemflow). Stemflow was estimated from a review of relevant literature. The selected indicator for soil water infiltration was the non-saturated hydraulic conductivity, which was measured using the Mini Disk Infiltrometer (Decagon Devices Inc.). The selected indicator for soil water holding capacity was field capacity of the mineral soil, which was calculated from pressure plate measurements of soil moisture content at 0.33 bars, using representative soil samples.

The greatest water retention potential was shown for mixed forest in the city center (80 scores), followed by floodplain hardwood forest (63 scores) and riparian pine forest (39 scores). The lowest water retention potential was indicated for urban grassland (22 scores).

Using natural vegetation to improve water retention in urbanized watershed represents a nature based solution. Results of this study could help to link the decision making incorporated in urban planning system with better urban water retention measures.

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Innovative delivery of flood alleviation through green infrastructure

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There is an increasing recognition that investment in flood risk management infrastructure offers many opportunities to bring wider benefits to society: improved water quality, habitat enhancement, public health and recreational improvements. However, this requires innovation in the design of new flood alleviation schemes and a broader appreciation of the role of green infrastructure.

Jonathan Vann, Managing Director of Riverscape Environmental Consultants and previously Senior Flood Risk Management Advisor for the UK Environment Agency, will discuss the way that both landscape and local scale interventions can bring significant reductions in flood risk to communities, often at a low cost in comparison to traditional methods. The technical challenges will be explored, alongside the opportunities offered by current modelling techniques.

Leicester is one of the cities in the UK at greatest risk of flooding. A number of green infrastructure schemes have recently been undertaken to reduce the risk of flooding. Chryse Tinsley, Landscape Architect at Leicester City Council, will discuss the practical application of sustainable flood risk management works in the city.

Belgrave is a suburb of Leicester to the east of the River Soar. One of the most densely populated wards of the city, Belgrave has a mixed community with more than 50% of the population born outside the UK. Levels of deprivation in this part of the city are high and cardiovascular disease is a major health issue. Chryse will describe how investment in flood alleviation through green infrastructure improvements has brought many wider benefits to the local community: improved public access to the riverside, the transformation of derelict spaces and the creation of new wetland habitat.

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Creating and Enhancing Green Infrastructure on a Site Level by Rainwater Management

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Green infrastructure is not only a fundamental concept for improving the urban environment, it is also a design topic. Green infrastructure comprises water management on different planning levels. On a landscape scale landcover determines surface run-off, floodplains and riverine forests retain floodwater, aquatic and semiaquatic ecosystems account for water purification. The ecosystem services are provided by natural and semi-natural areas.

In cities surface sealing and a climate change-related increase of heavy rain falls strain existing sewer systems to their capacity limit. Urban heat islands pose a growing health hazard. Possible remedies are greening communities to provide infiltration and evaporation. Landscape functions – reduction of surface run-off in catchment areas, detention and purification – are redesigned on a site level. This implies a paradigm shift in water management and open space planning towards integrative solutions. Rainwater management resorting to ecosystem services moves closer to the source and merges with open space design.

Water features are a traditional topic in landscape architecture, but the creation of multifunctional systems based on green infrastructure principles requires different design approaches. By analysing literature and case studies in Europe and North America three major design strategies were identified: Artful rainwater design highlights rainwater management as a site amenity. Concealment specifies designs in which water is rapidly removed from visibility. Integration describes designs in which the water flow is open, but the system and its components are not highlighted.

Enhancing green infrastructure on a site level must apply a mixture of these design strategies in attentive response to the site and intended use.

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Phyto-dehydration of confined sludge: a sustainable approach for the management of polluted ponds

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Leaf transpiration drives many of the processes involved in phytotecnologies, and it can represent a useful mechanism to remove water in basins containing polluted flooded sediments (phyto-dehydration), with the aim to reduce the risk of environmental contamination. This approach could be applied to different storage basins presenting inorganic, organic or microbiological contamination, as urban storm water detention basin, flooded mine pits, mine tailing and mine settling ponds, sedimentation basins in metallurgical plants, farm slurry storage lagoon and storage basin for landfill or waste-rock dump leachate. The presence of toxic compounds and the persistent water layer over the sediments require however an appropriate selection of the plant species and an accurate analysis of the responses of plant processes to the environmental constraints, including the pollutants present in the substrate.

In this framework, a mesocosm-scale experiment was carried out to test the capacity of different macrophyte species to reduce the excess of water in an artificial pond filled with oversaturated sludge deriving from sludge biodigestion (high zinc and copper content).

Plants were able to grow in the mesocosms and significantly increased (by 63% and 24%, depending on the species) the amount of water lost by the sludge/water system: furthermore the presence of plants counteracted the loss of organic carbon of the sludge (that could lead to a mobilization of the heavy metals bound to organic matter), cut down the rates of greenhouse gases emission and reduced the sludge pathogen (Enterobacteriaceae) occurrence.

In conclusion, this new phyto-technology can represent a suitable approach for the reduction of the water level of ponds filled with contaminated and oversaturated sediments.

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Analyzing and modeling urban soils' functions and ecosystem services in the New Moscow: consequences of urbanization and perspectives for urban planning

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Urbanization is responsible for substantial environmental consequences worldwide. Urban ecosystems and their air, water, vegetation and soil components are substantially different from those in natural environment. Urban soils provide important functions and services, including carbon sequestration, filtering and purifying surface run-off, supporting biodiversity and even storing cultural heritage. Urban soils' formation and functioning are directly and indirectly influenced by human, which shall be considered when analyzing and modeling urban soils' features and functions.

This study aimed to analyze functions and services of urban soils in the New Moscow – a recently urbanized 1500 km2 areas, included into the boundaries of the Moscow city in 2012. Soils located in different functional zones and having different land-use history (e.g. parks located on prior forested areas or residential blocks, occupying prior fallow lands) were analyzed. Data on SOC stocks, pH, nutrient contents, contaminants' concentrations and microbiological activity were used to map and analyze the capacity of urban soils in the New Moscow to provide functions and services, valuable for city dwellers.

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Monitoring of soil chemistry at greenstreet sites in New York City

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Bioretention performances on pollutant removal have been studied extensively, but relatively few have examined soil development in the context of stormwater capture. This research is part of a collaborative NSF RAPID grant where one Greenstreet (a type of bioretention systems) and two comparison control sites were instrumented for long term in-situ data and sample collection. The Greenstreet site receives street runoff from a catchment area of 223.5 m2, while a control site, about 0.4 miles away, receives only direct precipitation. The second control site is within an urban forest with relatively undisturbed land use and tree canopy. While hydrological monitoring and preliminary biological data collection have been mainly conducted by a research team from Drexel University, Brooklyn College researchers have focused on water and soil chemistry of the three sites.

Precipitation, runoff, and subsurface water samples have been collected during multiple rain events to evaluate chemical inputs to the systems and to determine pollutant and nutrient removal efficiency. Soil samples were taken at various depths of the soils profiles over the course of one year to establish baseline conditions and to evaluate the short term changes in the soils. The soil and water chemistry is evaluated in combination with hydrological and microbiology information to help better understand the biogeochemical and physical processes operating in the bioretention systems, and help develop an integrated model for pollutant fate and transport.

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Innovation in implementation, developing socio-technical tools to ease the implementation of new integrated stormwater management and urban greenspace water supply

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In this presentation, we present a novel model for developing knowledge for hard and soft technological solutions, to turn urban storm-water from a problem to a resource. In so doing, local storm water becomes the source of water supply for new urban planting of greenspaces. The model aims to improve the delivery of ecosystem goods and services and the quality of life for the urban population by creating a set of "hard" (scientific) and "soft" (socio-technical) tools, which can be used by stakeholders to implement integrated urban storm-water management systems in Norwegian cities.

The project is designed with a *transdisciplinary* approach to both knowledge generation and tool creation in order to avoid strong sectorial frictions between disciplines and stakeholders, which have been identified as a common barrier to implementation. It involves line organization, local leadership, scientists, businesses and citizens in an ARENA forum. Also key to this is the structure of the project which integrates different disciplinary orientations into each work package, helping avoid 'silo-ization' which can interfere with sustainable implementation of such projects.

The project addresses barriers to internal effective communication between government actors and between them and the public, who will ultimately plan, inhabit and/or pay for these urban environments. Innovative transdisciplinary solutions can help deliver the most sustainable effective urban environments. The outputs of the project will help make the implementation of sustainable urban storm water management systems easier and more efficient. This will deliver positive outcomes to urban places through improvement of both storm-water management and water supply to urban greenspaces.

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Poplar tree infrastructures to rehabilitate soils contaminated with polichloroorganics and heavy metals

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In the last few years, we are assisting to an increasing awareness that, in the field of land reclamation, nature-based solutions are mandatory in a context of environmental, economic and social sustainability. The use of green infrastructures with soil rehabilitation purposes (consisting of selected trees established at the high density of one plant per m2) has proved to safely interact till down to 0.70-1.00 m depth with organic and inorganic contaminants. Indeed, these high-density tree plantations establish a huge root network, which enhances the bacterial degradation of organic compounds and the extraction or immobilization of heavy metals. This solution has been used in a few *in situ* applications optimizing the expression of some metabolic and physiological functions by the "plant system", such as: transpiration, aboveground and underground growth, the photosynthetic and more generally gas exchange activities, the interaction of root apparatus with other soil biosystems.

The environmental, economic and social benefits offered by the use of this technique are numerous. Undoubtedly the primary environmental benefit is the fact that the reclamation process is "solar driven". In addition, plants while growing simultaneously interact with all environmental matrices, as well as with the target contaminants, really improving the quality of soil, water, air, and of the landscape in general. In this way, albeit more slowly, there is the possibility to achieve the objectives of the soil reclamation avoiding to create the "biological death" or an impoverished soil, that is produced as a result of some conventional methods for cleaning. From the economic point of view, the relative low cost of soil reclamation per unit area allows an application of this technology to extended regions, where other technologies would be impractical. From the social point of view, tree plantations are more easily accepted by the population than the conventional remediation techniques, as they contribute to a greener economy. Moreover, this practice gives the opportunity to field new "green" professionalism in different production sectors of the territory.

The proper application the phytotechnologies to reclamation processes is necessary in order to integrate the chemical characterization plans with ecological and agronomic aspects, given that the remediation planning is necessarily site specific. For the optimization of the different functional processes of plants, it is also necessary to create the proper environment for their growth, even implementing management systems and/ or specific infrastructures. The existing great biological variability needs *ad hoc* designed tests and pilot phases. For this reason, it is necessary to build planning teams with different skills and expertise.

Our research group practiced some successful examples of experimental applications of phytotechnologies aimed to cope with different environmental criticalities, most of them realized within National Interest Sites, contaminated with polychloroorganics (Hesachlorocycloexhane isomers, HCH, polychlorobiphenyls, PCBs) and/or heavy metals.

The green infrastructures utilized have proved a viable alternative to conventional systems for the rehabilitation of contaminated sites.

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Evaluating the potential of Urban Green Infrastructure to increase resilience to floods: comparative case studies from southern Italy

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Contemporary research on urban systems looks at resilience as a framework able to produce policies and projects that better integrate water and flood risk management in urban planning and design. Among the approaches for flood risk management, Green Infrastructure is increasingly being used in the storm-water literature as a way to implement Sustainable Urban Drainage System (SUDS) in cities. Integrating SUDS in planning choices might allow to increase the overall supply of urban Ecosystem services (particularly in terms of regulating and cultural services) and providing resilient and adaptive measures for flood risk management.

This paper shows the preliminary results of the evaluation of the effects of some SUDS on increase of resilience capacity for two urban catchments in southern Italy with different urban settlements and drainage network typologies, namely in Apulia and Sicily. A comparison between scenarios of pre-implementation and post-implementation of a set of SUDS (particularly green roofs) is carried out through catchment simulations. These scenarios are based on a set of urban and hydrological analysis and are simulated with the use of Storm Water Management Model (SWMM) in order to understand the beneficial effect of the adoption of SUDS on regulating urban water run-off.

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Three-dimensional tree: a new method to evaluate interception of rainfall

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Trees are essential elements of urban green infrastructure. Urban areas rely on tree ecosystem services such as rainfall interception. Tree cover directly affects the amount of water reaching the ground surface, and consequently the intensity of run-off effect. The quality of these services is dependent on tree-specific characteristics such as leaf area index. However, collecting information about these characteristics is time-consuming and costly. Terrestrial Laser Scanning (TLS) is gaining increasing attention as a method to directly measure 3D shape of tree canopy and consequently estimate different tree characteristics. The aim of this study is to use TLS data, collected by a handheld laser scanner, from different tree species and correlate these results with the interception of rainfall.

The three most common street tree species in the centre of the City of Melbourne, Australia, were selected: English elm (Ulmus procera), London plane (Platanus x acerifolia) and spotted gum (Corymbia maculata). Four trees of each species were scanned. After scanned, trees were placed on a balance and a rainfall of 0.42 mm/min was simulated, whilst the balance registered the mass of water intercepted for 15 minutes. At the same time, throughfall was collected in small tubes distributed under the canopy in a grid of 11 x 11 cm. The results showed a significant correlation between the density of scanned points and the maximum water storage capacity of different species of trees. This study contributes to an understanding of the complexity of evaluating the rainfall interception process by urban trees. Moreover, it encourages the integrated use of new technologies such as TLS into the assessment of trees, allowing us to predict the quality of environmental services with more confidence

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Urban Agriculture as a Type of Green Infrastrucure

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Climate change, a sustainable city, and the 'local food' and 'farm to table' movements has been catalyzing the growth of urban agriculture at a time when green practices and infrastructure are gaining popularity and are being implemented as an alternative or compliment to the grey infrastructure of the City. Urban agriculture is reclaiming vacant lands, community gardens, tree pits, and rooftops in New York City, and as such has become a type of 'Green Infrastructure'-intercepting rain water, and mitigating the heat island effect. Urban agriculture, as all green infrastructure, plays a role in soil remediation, conservation, and pollutant mitigation. Proper practices need to be considered in urban agriculture applications because the vegetation is grown for consumption. The following study focused on crops, however, the findings provide a valuable tool in mitigating effects of contamination in urban agriculture as well as any other GI application. Phosphate amendments are used to reduce Pb hazards in soil via the formation of stable Pb-phosphate minerals. However, the phosphate in soil can mobilize As. This study examines the Pb binding and As mobilization potential of phosphate and alternative amendments. Common produce was grown at an urban farm with elevated concentrations of Pb and As in the soil. Overall, tissue Pb and As concentration was affected by plant type than by amendments applied. Root crops had the highest levels of Pb and As, followed by leafy vegetables and then fruits. Evidence show that dust and dirt particles are the dominant contributors to plant contaminants. Crop selection, dust control measures, and conservation practices should be applied to reduce exposure and to mitigate the health health risk from soil contamination.

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Creating ecosystem services in stormwater wetland parks: Case studies in Southern Finland

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The challenges of urbanization and stormwater can be turned into placemaking for people and habitat creation for fauna. In the presented EU Life+ Urban Oases case study a nameless stream, which was disappearing in culverts at a rapidly urbanizing commuter town to the Metropolitan Helsinki area in Finland, was saved and changed into a chain of stormwater wetland parks including endangered clay stream habitat. The stream was first revived by restoring its old local name on maps. Since most of the watershed is urbanized and most of the stream is in a sewershed, the flows entering the still open stream sections are far from what the natural stream had experienced, and the stream itself could thus not be restored. While a decision was made to turn the remaining cleared stream into wetlands, the first severely eroding stream section worked on could not accommodate such aims due to space limitations both above and below ground. Planning at zoning level then preserved space for minimum a 60 meter wide park along the stream with no hardscape allowed even below ground. Two large parks have been constructed with area seven hectares each with 0,5 and 1,5 hectares of inundated wetland and clay stream habitat landscape. The parks have been monitored for their success in many ecosystem services such as vegetation self-establishment, water quality mitigation, carbon binding, habitat, and urban dweller´s valuation of the sites. It has been shown that vegetation rapidly self-establishes and fauna such as amphibians rapidly find the sites after designed landforms have been completed by excavation. The parks wetland areas do mitigate water quality and while the wet areas act as sources of methane the wetland plants efficiently bind carbon. While focus in constructing wetlands is often on water quality mitigation, the urban dwellers rather value the wetland parks for diverse and changing native plants and fauna as well as for recreation. The parks host a set of nature trails and a bird viewing tower which along with the lush landscape have given locals pride and a sense of belonging to a place.

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SESSION 2

GI for water and soil management and remediation

POSTER

Low-Growing Urban Vegetation: The Role of Leaf Morphology on Rainfall Interception and Retention

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Intensification of rainfall through climate change is impacting on many regions. In urban areas, increasing volumes and unpredictability of rainfall are exacerbated by soil sealing via hard impervious surfaces, thereby further increasing risks of flooding. Green infrastructure, however, can help mitigate urban flooding. The potential of trees to capture rainfall and slow runoff has been documented. However, the value of low-growing urban vegetation is less well researched, with the possible exception of some studies focused on green roof plants. In this research, therefore, experiments are conducted to determine the water-holding capacity of low-growing shrubs and herbaceous plants, and to determine if certain leaf traits affect raindrop capture and retention.

A small range of genotypes with contrasting leaf types and traits (e.g., *Bergenia, Vinca, Dianthus*) were chosen to determine their ability to retain water on their leaves. Retention rates are being assessed under different precipitation scenarios (e.g. large versus small droplet sizes). Preliminary results on individual plants suggest that fine-leaved species retain a proportionally greater volume of rainwater than coarse-leaved species (broadly agreeing with work on trees). However, these early results are being verified using a larger 'community' scale study via a rainfall simulator.

In addition to investigating the volume of water that can be held in plant canopies, the relationship with moisture levels in the substrate matrix is also under scrutiny. One example examines how different leaf traits and canopy size/orientations influence the ability to recharge the substrate moisture-holding capacity between subsequent rainfall events (e.g. via evapo-transpiration). The data is discussed within the context of utilising small-scale green infrastructure to influence urban stormwater flows.

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The value of “Yashikimori” as Green Infrastructure in Tokyo, Japan

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Tokyo had rapidly expanded after 1960s and became one of the largest cities in the world; however there are many relics of rural landscape still remaining within the city, such as irrigation channels, farmlands, and “Yashikimori”, which is privately owned coppice forests around houses. Originally, it played important roles of preventing winds, regulating temperature, providing foods, woods, and fertilizer etc. Recently, Yashikimori have been reevaluated as fundamental components of green infrastructure in Tokyo. This study identifies the transition of Yashikimori and related landscape elements, and investigates contemporary value and conservation measures of them. Particularly, the study focuses on rainwater infiltration capacity because the inundation risk caused by heat island phenomena has become a serious issue in Tokyo. The upper stream of Kanda River was selected as case study, where about 350,000 people living, 15 kilometers west of the central Tokyo. The capacity of rainwater infiltration was calculated using Horton's equation. The results revealed that the total capacity of rainwater infiltration of Yashikimori and farmlands was 29,990 m3/h, which was more than 30% of the capacity of the stormwater management facilities established by local municipality for the last ten years. In spite of this contribution, privately owned Yashikimori is easily subdivided into small lots because of extremely high price of land for housing. Therefore, supports from public and private sectors are necessarily. The fact of this study indicates that it would be possible to reduce sewerage charge of owners and/or to collect stormwater fee from citizens as environmental tax and distribute it to them, according to the capacity of rainwater infiltration of each Yashikimori.

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Blue green infrastructures for urban runoff control using a network of LID-BMPs. The case study of Naples

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Climate change and its effects on urban areas represent a current phenomenon of considerable importance for people life quality. The mitigation of climate change effects and adaptation to its impact requests new techniques and solutions. In details the management of urban water drainage systems assumes a considerable importance on the control of runoff impacts.

The effects of heavy rains on cities are well known, very often resulting in increasingly frequent flooding of urban centres.

In the new course of management of urban water drainage systems, an important role can be played by innovative design approaches, the Low Impact Development (LID) technologies of Best Management Practices (BMPs) related to the control of urban runoff. The main goal of these strategies is to increase urban resilience to risk of flooding.

In this paper the performances of the existing urban drainage system is analysed for a very densely urban area, recreating the pre-urbanization and post-urbanization "hydraulic scenario" through GIS applications.

The analysis phase will be followed by the implementation of possible design scenarios, and a project/plan to municipal scale, acting not only on buildings and pipeline system performances but also on the provision of LID-BMPs in order to create a urban blue-green infrastructure able to control the phenomenon.

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Barriers of change to sustainable stormwater management in the city of Malmö, Sweden

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Due to climate change and urbanization, traditional piped- drainage system is great challenged in the past decades with increasing urban flooding threated to people's lives and properties. Sustainable Stormwater Management (SSM) is recently considered as a useful way to decrease the negative impact. However, SSM is not implemented wide spreading in urban stormwater management. In this paper, we studied the barriers of change to SSM in the city of Malmö, Sweden in terms of six semi-structured interviews with organizers and practitioners of Malmö municipality.The aim of this paper is to understand how these barriers affect the receptivity of change towards SSM in Malmö. To analyze the data, we combined two theories: policy arrangement and receptivity model. The results show that lack of resources, lack of stakeholder involvement and insufficient legislation influence the awareness, association and acquisition of receptivity so as to influence the application of SSM in Malmö, Sweden.

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Flooding risk assessment in urban territories in Bulgaria

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Flooding over the Europe causes serious damages on infrastructure and took causalities during the recent decades. In Bulgaria the most considerable damages were from noted swellings of rivers in 2005, when disaster situation was observed almost in the entire country. In the next years many floods in different parts of the country were registered. The assessment of flooding risk in Bulgaria is made by implementation of methodology of the Ministry of Environment and Water of Bulgaria, accepted in connection with the execution of EU Water Framework Directive 2000/60/EU. The directive is applied by the Basin directorates and the areas at risk for the territory of Bulgaria are defined.

In the present investigation the methodical approach, based on the potential danger of flooding of urban was applied. The objective is to assess flooding risk at administrative regional level in connection to ecosystem services provision by green infrastructure. The results showed that for 28 administrative region the assessment is ordered as follow “bad” score (high flooding risk) - 17, “moderate” score (moderate risk) are 7, 3 are with “very bad” score and one is with “good” score.

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Modular green façade elements built from construction and demolition waste elements to treat storm- and greywater

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Construction and Demolition Waste (CDW) represents 31 % (850 million tons) of total waste generation in the European Union. Within the Green INSTRUCT project (Green INtegrated STRUCTural elements for retrofitting and new construction of buildings, grant agreement nr. 723825), the development and deployment of a prefabricated modular structural building block consisting of over 70 % of CDW in weight is a contribution to counteract this trend. It is superior to conventional precast reinforced concrete panels by virtue of its reduced weight, improved acoustic and thermal performance and multiple functionalities, including a modular green infrastructure incorporated in the exterior part of the panel. The concept, viability and performance of the developed modular panels will be verified and demonstrated in test cells. While the main functions of the internal panel are thermal comfort, seismic resistance, indoor air quality, fire protection, visual comfort and acoustic insulation; the external panel (the green façade) incorporates functions of aesthetics, biodiversity, physical resistance, acoustic insulation, air purification, and grey- and storm water management. Hardy evergreen plants like graminoids, sub-shrubs or herbaceous perennials for temperate regions will be planted in a substrate-filled geopolymer-matrix, derived from CDW. This green panel will purify storm- and greywater derived from washing basins, showers/baths, kitchen wastewaters, washing machines and other suitable sources. This green infrastructure will be capable to reduce the water quality parameters COD and BOD by more than 85 % and reclaimed water can be recirculated in the building. Additionally, the green unit will capture approx. 2,4 kg of CO2 per m2 and year.

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SESSION 3
GI for climate regulation and climate change resilience
ORAL

Keynote Speaker
Green Infrastructure and climate change resilience- accounting for context and community needs

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Anthropogenic emissions of greenhouse gases have forced global climate change. There is also increasing scientific literature on green infrastructure, its ecosystem structure, functions and services they provide humans. Accordingly, studies on, and tools for, managing these effects such as carbon dioxide sequestration, storm water and temperature regulation, plant selection and coastal effects are common. However, most of this information is from a few cities mostly in the global north despite the fact that biophysical and socioeconomic drivers of ecosystem services vary within and between cities. Similarly, these effects rarely take into account the human perceived needs and effects of climate change on communities, particularly more vulnerable populations. In this presentation, I will discuss an applied socio-ecological framework that considers context to better understand the functions and relevant ecosystem services of green infrastructure that are of value to residents in cities of the world. I will use applied case studies from Argentina, Brazil, Chile, Colombia, and subtropical North America integrating biometric plot data, geospatial and mathematical models, community perception surveys and econometric valuation models that account for the socioeconomic and biophysical context. Concepts such as green infrastructure, urban forests, nature-based solution, ecosystem services are useful for creating climate change resilient communities, but must be adapted based on the audience, community, and governance context.

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Hydraulic behaviour of expanded cork agglomerate in green walls and living facades

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Many European cities are committed to improve their environment and livelihood conditions despite the challenges posed by increasing urbanization and climate changes. In this context, green walls and living facades may offer extensive benefits to cities, since they have the desirable potential to reduce urban heat island effect, improve air quality and restore biodiversity. Additionally, green walls and living facades may also improve the thermal insulation and increase the energy efficiency of buildings.

Expanded cork agglomerate is an environmentally friendly material with improved features of water retention and thermal insulation. For this reason, this material is a good candidate to enhance the performance of green walls and living facades. In this communication, the hydraulic behaviour of expanded cork agglomerate is analysed in terms of permeability and retention capacity. For this study, variations in the density, high and thickness of cork agglomerate boards were considered.

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Qualification of carbon stocks based on imperviousness of urban areas: a case study from Istanbul[1]

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The greenhouse gas emissions and removals from settlements constitute a significant amount in fast urbanizing countries. It may involve a conversion from/to other land uses or an urban area may become more intensively urbanized. The urban land use is reported under Settlements category in Land Use Land Use Change and Forestry (LULUCF) sector of the Greenhouse Gas (GHG) Inventories in the context of the United Nations Framework Convention on Climate Change (UNFCCC).

In this study we combined land surveys together with land cover data in an effort to estimate carbon stocks in urban/suburban areas in Istanbul. The carbon stocks for the pools have been calculated on 59 sample plots. The study is conducted in temperate climate conditions. The carbon stocks of impervious areas have been calculated based on the country specific emission factors in the context of the TUBITAK 112Y096 project. The following methodology has been applied;

1. The study area (582 km2) has been divided into 500*500 meter grids,
2. The land uses in each grid have been determined from SPOT6 2013 satellite image with a 1.5*1.5 meter resolution using supervised classification,
3. The accuracy check has been performed with 1000 plots with over 90 percent accuracy,
4. The land use in each grid has been multiplied by carbon stocks,
5. The impervious areas in each grid has been grouped under 5 classes that are >20 percent, >40 percent, >60 percent, and >80 percent. The project area has been classified for 4 intensity classes in this way.

According to results the urban areas that have more than 20% imperviousness have 78.16 Mg C /ha in all carbon pools (aboveground, belowground, ground vegetation, litter, and soil) while urban areas more than 80% imperviousness have 17.27 Mg C /ha. Based on the results of this study we calculated the emissions and removals due to conversions from other land uses to the impervious areas in Turkey. In 2013 the net emissions from land converted to impervious areas has been estimated to be 570.61 Gg CO2 eq.

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Assessment and mapping of climate regulation ecosystem service in Bulgaria

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Urban landscapes provide a number of benefits for the human society through supply of ecosystem services. Mapping of ecosystem services has broad application potential since it is an extremely valuable method for visual representation of qualitative and quantitative spatial data. Green infrastructure in the cities is of the key importance as a source of range of benefits like air filtration, city climate regulation and carbon storage, connectivity between natural systems, biodiversity, community cohesion etc. In present study an approach to assess and map climate regulation ecosystem service in urban areas at national level is proposed. As urban condition is dependent on many factors, the combination of building and land cover types in urban territories is informative complex indicator for assessment the urban ecosystems condition. The value of parameter “carbon storage in green infrastructure" applied to the complex indicator gives information about the capacity of carbon stored in different urban landscapes and for the role of greening in climate regulation. The share of carbon in urban green areas in both soil and vegetation is not dominant but their capacity to store carbon (tC/ha) is utmost. The carbon storage in soil and vegetation is strongly influenced by the land cover type in the area therefore the assessment has to be carried out in accordance with an analysis of the spatial infrastructure of the respective territory. The proposed approach for mapping the carbon storage in green infrastructure of urban territories as indication for climate regulation ecosystem service can be further applied in implementing the requirement of the EU Biodiversity strategy.

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Urban green infrastructure as a tool for mitigating the urban heat island – a review of research methodologies

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While the combined trends of city growth and global warming bring about increasing aggravation of thermal stress in urban areas, urban green infrastructure (UGI), trees and urban forests in particular, have unmatched potential to mitigate the urban heat island (UHI) effect and to enhance human comfort. The review is a survey of research approaches and findings in 90 studies, which deal with the contribution of UGI to UHI mitigation and to human comfort, in Mediterranean, arid, Atlantic and Boreal climatic regions in Europe and Israel.

The methodology most widely used is the quantification of the cooling effect of UGI, based on field experiments, mostly at the micro-scale and short periods (up to a few days). The studies cover all seasons, almost half of them referring also to the cold season. About 1/3 of the studies contain numerical models of the UGI contribution to human comfort and less than 20% of them make use of questionnaires to evaluate subjective perceptions of thermal comfort.

Urban trees were found to be the most effective tool to mitigate the UHI and to enhance human comfort, with additional benefits to ecological functions. Nevertheless, very few studies referred to particular tree species or to amount of coverage by foliage or tree coverage, subjects deserving further research. The variable most commonly measured was air and/or surface temperature. Studies focused on human comfort and microclimate modelling also used solar radiation, humidity and wind speed, to model the energy balance.

For optimal benefit from UGI research there is a need to study the combined effect of various green measures: vegetated terrain, green walls and in particular street trees and urban forests, as well as analyzing the applicability to urban planning and the translation of the general principle into a set of practical rules for city planners and UGI managers.

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The role of green infrastructure on urban climate – insights from the Copernicus Climate Change Service

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There is strong scientific evidence showing that the interactions of grey and green infrastructure are key drivers of urban climate. In UrbanSIS, a proof-of-concept project within the Copernicus Climate Change Service (C3S), we are interested in knowing how, and to what extent, urban planning affects the city´s response to the climate signal.

The urban downscaling of the Numerical Weather Prediction system HARMONIE is carried out with the Town Energy Balance (TEB) model, with lateral boundaries provided by the UERRA reanalysis. Detailed land-cover is included through the implementation of a method for generating refined 1x1 km2 resolution physiography data over urban areas. For this purpose, open-access data from ECOCLIMAP-II, Urban Atlas 2012 (Copernicus Land Monitoring Services), OpenStreetMap, and leaf area index (Copernicus Global Land Service) are processed and aggregated.

In this work, results for a 5 years period over Stockholm, Sweden, and preliminary outputs for Bologna, Italy, are shown. The model data is compared against local meteorological observations within the city and rural outskirts. Emphasis on the analysis of data from the Observatoriet weather station in central Stockholm, a 4 ha urban park, is given with the aim of quantifying the magnitude and dynamics of the park cool island (PCI), and its impact on the city´s urban heat island (UHI). The ability of the model to represent the physical processes involved in the interaction of vegetated and built-up surfaces with the atmosphere is discussed.

By delivering high-resolution urban climate data over European cities, UrbanSIS aims at providing new insights into the potential of Nature Based Solutions (NBS) to deliver innovative and efficient solutions for adapting to climate change.

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Urban vegetation as carbon reducing ecosystem service in Helsinki

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Urban areas are major emitters for carbon dioxide (CO2), which is the most important greenhouse gas in the atmosphere. Emission inventories are used to estimate CO2 emissions from cities, but these commonly lack information about the effect of urban vegetation on the emissions. However, for cities to reliably estimate their CO2 emissions, also vegetation should be included as it can be an important component of the CO2 balance.

In this study, the biogenic components of net urban ecosystem exchange (NUE) will be determined for Helsinki using the Surface Urban Energy and Water balance Scheme (SUEWS). The model has recently been developed to include the surface exchange of CO2 as one of its simulated components. The biogenic components of NUE will be parameterised based on the non-rectangular hyperbola (NRH) equation, which gives the vegetation uptake relative to light-response curve, and air temperature dependent respiration.

The model will be run over a three-year period in Helsinki centre (6x9 km2) using measured meteorology as forcing. The studied area will be divided into 250x250 m2 grids and for each grid, model parameters will be independently calculated. The plan area fractions of different surface cover types (buildings, pavements, evergreen and deciduous trees, grass and water), and building and tree heights will be obtained from scanning lidar with 2 m horizontal resolution. The parameterizations for the NRH equation will be obtained from eddy covariance (EC) measurements of CO2 exchange, and for respiration from soil chamber measurements made in Helsinki The results show how SUEWS is able to reproduce vegetation uptake and respiration well when compared to EC measured CO2 exchange at two locations in Helsinki.

Furthermore, we will examine what is the effect of vegetation on CO2 exchange relative to anthropogenic emissions and what is its seasonal cycle in Helsinki.

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Green walls to control microclimate inside buildings

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Building indoor air temperature depends on several different parameters related to the climate of the region, the building itself and its use. The main parameters influencing the microclimate are: external air temperature and relative humidity, incident solar radiation, long wave radiation exchange between the building surfaces and its surroundings, incidence and speed of the wind, air exchanges, physical and thermal properties of the building's envelope materials, design variables such as building dimensions and orientation, presence of artificial light, electrical equipment. The green technology can represent a sustainable solution for construction of new buildings and for retrofitting of existing buildings, in order to reduce the energy demands of the buildings' cooling systems, to mitigate the urban heat island and to improve the thermal energy performance of buildings. Green walls can allow the physical shading of the building and promote evapotranspiration in summer and increase the thermal insulation in winter. An experimental test was carried out at the University of Bari (Italy) for two years. Three vertical walls, made with perforated bricks, were tested: two were covered with evergreen plants (Pandorea jasminoides and Rhyncospermum jasminoides) while the third wall was kept uncovered and used as control. Several climatic parameters concerning the walls and the ambient conditions were collected during the experimental test. The daylight temperatures observed on the shielded walls during warm days were lower than the respective temperatures of the uncovered wall up to 9°C. The nighttime temperatures during the cold days for the vegetated walls were higher than the respective temperatures of the control wall up to 6°C.

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Mapping and classifying green infrastructure typologies for climate-related studies based on airborne remote sensing data

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Despite the ample evidence on the thermal benefits of green infrastructure (GI), further research is still needed to investigate how cooling capacities are influenced by particular types, amounts, and arrangements. However, there are no commonly agreed typologies that can be confidently used to compare and report the existing climatological evidence. Two previous studies were conducted to respond to this gap, and a conceptual GI typology was developed according to functional, structural and configurational attributes. The present research tests its applicability by proposing a method for an automated mapping and classification of GI based on airborne remote sensing data. A combination of parameters is introduced, including surface cover fractions and FRAGSTATS metrics estimated from high resolution hyperspectral imagery, LiDAR and cadastral data. The proposed method can be applied at different spatial scales to analyse large urban areas in a shorter time and with higher spatial accuracy. This paper also proposes a replicable workflow that can be implemented to map existing vegetation conditions, prioritise greening interventions and deliver cooler neighbourhoods with greater confidence. In this study, this workflow was successfully applied at local scale to classify green open spaces, tree canopies and water bodies in the city of Sydney. Although the typologies identified here were initially designed to evaluate and compare the microclimate regulation capacities of GI, the method may also be applied for performance assessment across other ecosystem service categories. Furthermore, it aligns with other classification systems such as the local climate zones (LCZ). Future stages of this research will focus on statistical analysis and thermal comparison of typologies.

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Planning for cooler cities: A framework to prioritise urban green infrastructure

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Warming associated with urban development will be exacerbated in future years by temperature increases due to climate change. The strategic implementation of urban green infrastructure (UGI) e.g. street trees, parks, green roofs and facades can help achieve temperature reductions in urban areas while delivering diverse additional benefits such as pollution reduction and biodiversity habitat. Although the greatest thermal benefits of UGI are achieved in climates with hot, dry summers, there is comparatively little information available for land managers to determine an appropriate strategy for UGI implementation under these climatic conditions. We present a framework for prioritisation and selection of UGI for cooling. The framework is supported by a review of the scientific literature examining the relationships between urban geometry, UGI and temperature mitigation which we used to develop guidelines for UGI implementation that maximises urban surface temperature cooling. We focus particularly on quantifying the cooling benefits of four types of UGI: green open spaces (primarily public parks), shade trees; green roofs; and vertical greening systems (green walls and facades) and demonstrate how the framework can be applied using a case study from Melbourne, Australia

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Quantifying the microclimatic effects of urban green infrastructure for climate change mitigation and adaptation

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Rising temperatures and the intensification of the urban heat island (UHI) effect due to climate change are major challenges for cities. Adaptation via green infrastructure (GI) can significantly reduce the UHI effect. Our study aims at quantifying GI measures at urban micro-scale with benefits for outdoor as well as indoor thermal comfort and buildings' energy demand by coupling microclimate modelling with thermal building simulation. We use the microclimate model ENVI-met to analyse outdoor thermal comfort conditions in different urban greening scenarios. In order to evaluate the effect of these scenarios on indoor thermal comfort and buildings' energy demand, we employ IDA-ICE, a building performance simulation tool. As ENVI-met operates at a temporal resolution of single extreme weather days while analyses of energy demand and thus CO2 emissions are based on yearly records, yearly weather files are clustered into typical-day categories. For each of the typical-days an ENVI-met simulation is realized. The results of these calculations are the input for the building simulation. The input files can be measured data as well as climate change scenarios to study the effects in a projected future climate. The methodological approach is tested for an urban block in Munich, Germany, representing a typical urban fabric of residential buildings with a high degree of compactness and surface sealing. The study allows a detailed analysis of how GI measures at building level (green roofs and facades) as well as in the public space (street trees) are reducing the potential for indoor and outdoor heat stress for the typical-days of a year. The results are expected to serve as decision support for urban planners and city administrations when implementing GI measures.

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Mapping the spatial distribution of the nocturnal cooling service provided by a city's greenspaces under a temperate climate

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The 'urban heat island' (UHI) effect, which increases air temperatures in cities compared to surrounding rural areas, is a serious issue compromising the health and well-being of urban residents. Urban greenspaces can help mitigate this effect, as air temperatures are typically lower within greenspaces than in built-up areas and this cooling service may extend out beyond the greenspace boundaries, cooling the neighbouring urban areas. Little is known, however, about how this cooling is distributed throughout a highly urbanised city. Using London, UK as a case study, a methodology to map the extent to which a city's night-time UHI may be counter-influenced by its greenspaces is presented. Based on academic evidence collected by studies in temperate climate cities, this mapping exercise uses a Geographic Information System to spatially define and quantify the nocturnal cooling potential of greenspaces. The intensity and the dispersion of the cooling are considered, based on their relationship with greenspace size. Nest steps to improve the methodology are also discussed. This study visually illustrates the value of this important 'climate regulation' ecosystem service and can be employed to showcase the need to protect and expand London's greenspace or, more widely, the greenspace from other temperate cities where the UHI is a threat. It can also be used to inform response strategies to heat events and guide the strategic placement of new greenspaces to improve a city's resilience under a present and changing climate.

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Assessment of the microclimatic impacts of urban green infrastructure based on local climate zone classifications

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Urban planners and landscape architects need detailed information about the thermal conditions of open spaces for their design decisions. The urban microclimate is a key factor for the livability and sustainability of a neighborhood. It is unique in any given location as it is mainly dictated by the diverse nature of the local physical environment, which alters the overall climate of the region. The microclimate at the street and neighborhood level can vary greatly within relatively short distances because of differences in solar exposure, wind speed, humidity, and air and surface temperatures. The overall thermal comfort of the environment determines the functionality of a space and its use by humans.

In this study, a method is proposed to quickly assess the urban microclimate in relation to green infrastructure typologies at the local scale using four variables: surface albedo, wind speed and direction, evapotranspiration rate and the percentage of shade in each local climate zone (LCZ) based on the Stewart and Oke (2012) classification. With this in mind, a pilot case study with mixed land use was selected in the Sydney, Australia area and the above four parameters were applied to each zone in the software ENVI and GIS. Cloudless Landsat 5-7-8 remote sensing images with a combination of different bandwidths were used as a source for the land surface classification. To conclude, a set of planning recommendations in the form of a reference framework is proposed by the authors. This framework is intended to help urban planners and landscape architects evaluate microclimatic performance of green infrastructure with limited data, and to provide guidance on the planning and design of urban green space which optimises microclimate outcomes.

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Estimating the cooling capacity of different types of GUI in cities)

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A well-designed green urban infrastructure (GUI) significantly contribute to the wellbeing of citizens through the provisioning of ecosystem services (ES). Thus, the creation and restoration of GUI in cities to enhance the supply of ES has proved to be a promising strategy to achieve better climate change adaptation and a better quality of life for people within the city. Despite this, in everyday urban planning implementation is lacking. One on the major barriers is the lack of proper tools to inform city governments about the benefits they can expect from green urban infrastructure. Knowledge in this field has grown in the last decade, but still the assessment tools tend to be too broad (regional-national scale) or too specific and fragmented to be handle by public dministrations.

Our goal with this paper is to provide a conceptually simple and easy to apply approach to estimate the provisioning of one specific ecosystem service –cooling, and thereby to support planners and decisionmakers in the creation and restoration of GUI for cooling their cities and increase their resilience to heat waves and mitigate urban heat island effects. The approach is integrating knowledge from various disciplines, requires a limited amount of input-data and is at the same time able to distinguish between the cooling capacity of different types of GUI. Expected outputs from the approach are the identification of the most promising GUI for cooling capacity and a simplified methodology to estimate and map the cooling capacity of GUI in a city. Application in illustrative case study for the city of Amsterdam (NL) and Trento (Italy) are presented. The approach captures how different structure components contribute to the cooling capacity: differences may run up to 5-6°C.

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Selection of green roof substrates and plants to maximise the green roof thermal performance in South-East Australia

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Due to their ability to reduce stormwater runoff, lower surrounding air temperature and reduce building energy consumption, green roofs are increasingly being built as a climate change adaptation strategy that can help cities be more sustainable and resilient.

Green roof research done in Mediterranean climates with hot and dry summers indicates that green roof thermal performance varies significantly and further research is needed.

We investigated the thermal performance of green roofs in south-eastern Australia using field, controlled and semi-controlled lab set-ups. The thermal conductivity of three commonly used green roof substrates composed of scoria, crushed roof tile or bottom-ash, were quantified under different moisture conditions. The scoria substrate was the most insulating substrate with R-values for a 10-cm thick green roof from 0.24 to 0.74 Km-2W-1. Scoria substrate was tested to examine its insulation function in 18 planted green roof modules in semi-controlled set-up and for three experimental non-vegetated and vegetated green roofs on a 1940's building.

We tested drought tolerant plants commonly used on South-East Australian green roofs, such as Sedum pachyphyllum, and Australian plants, specifically Stypandra glauca, Dianella admixta and Lomandra longifolia, which are high-water users when water is available. Results showed that Lomandra and Dianella enhanced the insulative performance of the green roof by reducing green roof surface temperature due to higher evapotranspiration rates than Sedum and due to larger water retention than Stypandra.

In conclusion, this research showed the importance of proper substrate and plant selection to maximise the green roof thermal performance, and quantified its thermal performance for Mediterranean climates.

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REBUS® training programme and 'Rigenerare la città con la natura' toolkit - Designing public spaces for climate mitigation and adaptation

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REBUS® [REnovation of public Buildings and Urban Spaces] is a simulation game workshop conceived by the Emilia-Romagna Region for urban regeneration. It focuses on climate proof and nature-based solutions for urban heat islands mitigation and sustainable urban rainwaters management.

The workshop aimed at the public spaces transformation of three high-density neighbourhoods with different urban morphology: two industrial areas in Parma and Modena, respectively from the first half of the XX century and the Post-Second World War period; large areas in the city centre with parking facilities and open-air market in Rimini.

The teams – made of architects, urban planners, agronomists, landscape designers, engineers and public administration technicians – developed a project with specific solutions for each district:

- implementing functional green areas and planting trees along streets, in squares and parks to create a continuous and contiguous green infrastructure to mitigate summer temperatures;
- de-paving the exceeding asphalt, replacing it with permeable surfaces, rain gardens, retention basins and flood ditches to manage enhanced precipitations events in situ;
- replacing paving surfaces giving priority to the hard materials with higher albedo to reduce heat absorption;
- demolishing parts of the denser urban pattern, restoring parks and public spaces.

During the workshop, 'Rigenerare la città con la natura toolkit' http://bit.ly/RIGENERARELACITTACONLANATURA was tested by participants in order to find the most suitable mineral and green materials and design solutions.

The proposed transformations, measured with the software Envimet, reduced perceived temperatures, proving to be effective in terms of climate mitigation and adaptation.

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Ecourbanism – where ecosystem services and culture combine

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Simultaneous consideration of macro, meso and micro scales inform a whole system approach to resilient city building, renewal, and maintenance that I term Ecourbanism. In 2016 the world crossed a significant environmental threshold that will affect us all – an average 400 ppm of atmospheric carbon. This level is much higher than at any time in our collective history as a species, and it has the potential to alter many ecosystems. Cites can be considered as complex ecosystems that place stresses on both remote and neighbouring ecosystems; they are also home to over 50% of the global human population today, and to at least 70% of humans by 2050. The World Bank forecast in 2010 that the same quantum of urban areas that had existed in 2000 would be replicated by 2030. A significant fraction of materials extracted from the planet are stored in man-made infrastructure, and the construction industry produces some 40% of all human generated waste, therefore resilient cites must do more with less. Whilst close proximity of people can be the driver for innovation, it has also degraded ecosystem services that provide for us and other life. The increasing separation of Homo urbanus from Nature needs to be bridged; 'place' and 'identity' is important to us and our well being, so multifunctional biodiverse Green infrastructure should also be informed by aesthetic or spiritual qualities of local managed rural landscapes. In other words, simply wilding areas of city to bolster or retrofit supporting, provisioning and regulating ecosystem services is not the only solution, because local landscape character or historical culture also has a role to play. This paper considers a pragmatic biophilic approach to urbanism that I have applied to my work that respects life and landscape, and highlights the need to weave together people, water, food, energy and biodiversity to make the urban fabric more resilient to future environmental change both locally and globally.

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Assessment of the role of green infrastructure in the city of Bolzano (Italy) with WRF/SLUCM model simulations

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In recent years, the use of vegetation to mitigate undesirable urbanization effects has received increasing attention, being able to improve resiliency and maintain livable cities. The planning of sustainable policies and infrastructures such as green roofs should therefore be carefully considered, especially if the intended aim is an efficient use of environmental resources, and improve the quality of the urban environment. In the present work the effects of green infrastructures on local climatic conditions is assessed, taken as a case study the city of Bolzano, which is located in the north-eastern Italian Alps, in a basin at the crossing of three valleys. Climatic conditions in the city are tightly connected with the complex topography of the surrounding area, influencing in particular the flow field, mainly characterized by daily-periodic up- and down-valley winds from tributary valleys, especially in the warm season. In this context, high-resolution simulations with the Weather Research and Forecasting (WRF) model coupled with an advanced urban parameterization scheme are carried out, focusing in particular on the impact of different mitigation strategies, involving the use of vegetation (green roofs), on climatic conditions. A fine-scale analysis of urban vegetation and green infrastructure distribution is performed to provide high-resolution input datasets for the urban parameterization scheme, considering the current and ideal green cover scenarios. Model results are first validated by means of comparison with data from a network of permanent conventional weather stations in the area. Then, the thermal improvement led by vegetation cover is estimated both at the city and at the local scale, investigating the thermal characteristics of the Urban Canopy Layer.

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The microclimatic effect of Green Infrastructure (GI) in a mediterranean city: the case of urban park of Ciudadela (Barcelona, Spain)

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The use and promotion of Green Infrastructure (GI) is of great importance for improving the urban climate and for getting some cities more resilient and sustainable under the climate change. For this reason it has great interest the knowledge of the urban parks effect on the climate regulation of the cities. Temperature measurements were made during 16 nights in the winter and spring of 2015 in the biggest park of the Mediterranean city of Barcelona (Spain): the park of Ciudadela. The analysis of the temperature differences between the inside of the park and its urban surroundings has allowed to confirm the existence of an urban cool island (UCI) with an maximum intensity of 5.2ºC in winter, with anticyclonic weather types preferably, and a average intensity of 2.7ºC. In the spring months, the UCI has less intensity.

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Urban trees - cooling down the heat island: Do species matter?

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Ever increasing urbanization and replacement of natural vegetation with artificial surfaces increases the heat storage within the urban boundary layer and creates the"urban heat island (UHI)". Ongoing climate change is likely to exaggerate the problem and urban greenspace seems to be the most feasible option to mitigate UHI and adapt to climate change. However, the mechanisms of sensible and latent heat fluxes relating to the tree canopies are not well understood, as well as the influence of species characteristics. Therefore, we designed an experiment to clarify the impact of the cooling effectiveness of two common urban street tree species, Tilia cordata and Robinia pseudoacacia, on vertical and horizontal temperature profiles in the urban canopy layer (UCL). The project investigated the cooling performance of 20 individuals, during the summer 2016 in Munich, Germany. Not only tree morphology and transpiration were measured, but also micro-meteorological variables, such as air and surface temperatures. With higher leaf area index and growth rate T. cordata showed two times more transpiration compared to R. pseudoacacia, correspondingly reducing the air temperature (ΔT) within the UCL . Midday ΔT between the centre of the tree canopies compared to 3 m and 1.5 m height from the ground for T. cordata was around 1-2 °C whereas for R. pseudoacacia the ΔT was less than 1 °C. Thus the study can significantly contribute towards the understanding of cooling performance of two tree species of contrasting wood anatomies. The results can be used for micro-climate models to upscale the effects to macro-scale as well as help the urban planners to select appropriate species and growth conditions to maximize the cooling effects of urban trees.

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Summer surface temperatures of residential buildings in the city of Parma: the effect of imperviousness in different urban areas

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The rapid and unplanned urban growth is responsible for the continuous conversion of green or generally open spaces into artificial surfaces (imperviousness). The high degree of imperviousness triggers a rise in local surface/air temperatures especially in densely built-up areas, emphasizing the thermal spatial variability and contributing to modify the microclimate enhancing the urban heat island effect. At present time, no studies have quantified the influence of surrounding imperviousness specifically on the surface temperature of residential buildings (STbuilding). This topic represents the aim of the present study carried out in Parma (North Italy). NASA ASTER scenes (TIR resolution 90m) were used to analyze two summer clear sky days during 2015. The recent ISPRA high-resolution (10 m) of Italian built-up-surfaces database was used to estimate the local imperviousness degree (ID). The average STbuilding (n=10,444) and the ID density (%) bounded in a radius of 57m (ID_57) and 100m (ID_100) from each residential building were assessed. The relationships between ID and STbuilding were investigated in typical dense built-up and park/rural urban areas. Post-hoc ANOVA, Generalized Additive Model (by using building RGB reflectance as confounder) and break-point analysis of ID detection were applied. Significant daytime and nighttime STbuilding differences ($p<0.001$) between built-up and park/rural areas were observed, with the highest one (almost 2 °C) during daytime. STbuilding significantly increased nonlinearly going from the lowest to the highest ID frequency, especially during daytime when clear ID break-points were assessed for different urban areas. These results could help to identify "residential building Hot-Spots" that would benefit most from mitigation actions.

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Evaluating heat stresses on marathon runners and spectators in Tokyo 2020 Olympic Games

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Tokyo 2020 Olympic Games is planned to be held from late July to early August in Tokyo. Among various challenges to hold the world's largest sport event, one of the most serious concerns is the risk of heat stresses on athletes and spectators of outdoor games including marathon, as August is the hottest month in Tokyo. This study aims to estimate heat stresses on runners and spectators of the Tokyo 2020 Olympic marathon, and discusses measures to mitigate stresses by urban greeneries. The study applied a four-step procedure as: a) observe repetitively thermal conditions along the proposed marathon course in early August when the marathon races will be held, b) estimate heat stresses on runners and spectators by applying an outdoor thermal comfort model (COMFA), c) identify spots along the proposed marathon course where runners and spectators may be exposed to extreme heat stresses, and d) discuss measures to mitigate the heat stresses by urban greeneries. Out of 14 days of observations the heat stress on runners was the highest on 9th August, when 40% of the course was identified as "extreme dangerous" and 60% was as "dangerous" for runners. Especially, the course identified as "extreme dangerous" continiued for 9.8km in the latter half of the homeward, where every possible measure should be taken to reduce extreme risks on runners. Urban greeneries are expected to play an important role to reduce heat stresses on runners and spectators. In particular, creating more shades by restrict pruning street trees along the course and installing temporal containers with various types of greens are deemed to be effective measures to reduce the heat stresses.

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Evaporative cooling by urban forests: quantifying and valuing this ecosystem for three UK cities

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Trees provide important ecosystem services (ES) to urban human society and their absence can lead to recognisable environmental and social consequences. E.g. the urban heat island effect (UHI) is becoming more pronounced under a changing climate; propagating heat stress and agitating associated health problems. There is a positive correlation between areas which suffer from UHI and those lacking evapotranspiring surfaces. Evapotranspiration (Et) cools air temperature by converting solar energy into latent heat, lowering the amount of energy available to warm the urban realm.

This study models Et cooling using a comprehensive review of published Et values, and leaf areas reported in i-Tree Eco studies for three UK cities. An enthalpy-based approach was adopted to calculate Et cooling from trees considering temperature, humidity and latent heat of evaporation. The impact on local air temperature was compared to the efficiency of an active direct evaporative cooling system. A value of Et cooling from urban trees could be derived based on the cost savings in building energy use.

Urban trees provide significant urban cooling. The case study examples demonstrated that Platanus hybrid, Castanea spp. and Tilia euchlora performed extremely well compared to other species. Valuations based upon building energy use are also presented.

This research highlights the shortage of published Et data, particularly in urban environments, and illustrates differences between tree species, stock and condition in Et cooling. Inclusion of evaporative cooling could improve ES valuation models, such as i-Tree Eco, by producing a more complete picture of ES value to urban society. This is important for understanding the benefit-to-cost impacts of urban trees amidst funding pressures in the UK.

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Suitability of urban morphology types for Urban Green Infrastructure

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Urban Green Infrastructure plays an important role in reducing the effects of climate change by providing both carbon storage and sequestration. During the past decades increasing urban growth and sprawl processes produced several forms of urban areas characterised by different layouts of buildings density and related open spaces. Investigation of relationship between urban morphology carbon emission and carbon sequestration provided by UGI is a relevant topic for urban planning practices implemented to face urban climate change effects. In this perspective, this study proposes a method for assessing the suitability of different urban morphology types to accommodate new components of a potential UGI by spatially investigating their transformability.

The case study is the metropolitan area of Catania (Italy), characterised by an impressive urban growth since the 1960's. The proposed method identifies limits and options for increasing resilience of urban areas through the contribution of UGIs within differentmorphological types of built-up areas. Furthermore, this approach allows to identify appropriate planning tools for new layouts of urban fabrics while increasing the objectivity of the decision process. In the framework of climate change adaptation, the outcomes of this research may lead to innovate urban planning practices.

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Evaluation of heat-flux parameters of green roof models in Mediterranean climatic conditions

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One of the valuable effects of the green infrastructures is the mitigation of the "heat island" effect in urban environment. The installation of green roofs and facades can have an insulation effect on buildings, as result of the plant transpiration and the canopy shade. In previous studies we have evaluated plants and substrates suitable for green roof installations in the Mediterranean regions characterized by heat and drought in the summer (Di Bonito et al. 2016, Acta Horticolturae, in press). In this work we have monitored the heat flux of green roof models installed on a terrace in a Rome. The models were realized with Mediterranean species and soilless substrates on platforms with an interspace between the bottom and the terrace floor. They simulated respectively an extensive green roof, with substrate depth of cm 6, covered with a mix of Crassulaceae species, and an intensive green roof with substrate depth of cm 15 and shrubs (Lamiaceae). The temperature of the substrate and the interspace, the heat flux, and the weather conditions were daily recorded using a datalogger. The installations were realized in the summer 2014 and the plants reached a coverage of 80% of the surface after one year. The results obtained during three years monitoring have shown in the summer an average decrease of the temperature of 3 °C - 5 °C in the interspace under the structures respect to the atmospheric value. The development of the plant canopy and the increase of biomass over the seasons had a significant effect on the reduction of temperature of the substrate and the interspace. The results could predict an effect of insulation of green roofs installed on buildings in Mediterranean regions.

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Numerical study on the cooling effect of vertical greening in a high-density city: case study of Hong Kong

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In the quest to improve outdoor thermal environment and reduce indoor energy use, greenery strategies include façade greening have been suggested based on the fact that building surface area (especially in high-density cities like Hong Kong) is much greater than the roof and ground surface area combined. However, scientific evidence to ascertain this still relatively scant, thereby hampering implementation by urban planners and landscape architects. To partly fill this void, this study answers the following questions: How much façade greening per unit building surface area is enough for significant urban cooling? What is the effect of increasing or reducing urban density on the potential cooling by façade greening? Since it is impractical to green the four facades of buildings, which side (s) is most efficient for pedestrian air temperature reduction?

Answer to these questions were sought by parametric/numerical experiments using ENVI-met V4.0 model. Several sensitivity parameters such as building height, percentage of greenery coverage and greened façade were tested. Results show maximum temperature reduction when the four facades of all building in a neighborhood are greened while the effect reduces with reducing green coverage area. Between North/South and West/East walls greening, the later seems more efficient although it is more related to higher total surface area than orientation due to our urban layout. Lastly, our result revealed that the cooling impact increasing with increasing urban density which is likewise related to total building surface area. Based on our findings, practicable recommendation were given for urban planner and landscape architect for effective implementation of façade greening.

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Experimental methods for the estimation of green roof evapotranspiration

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Green roofs (GRs) are well-known for their hydrological performances. Their abilities to retain storm water are mainly influenced by the initial water content of the substrate prior to a rain event. The evolution in time of the water content is driven by the evapotranspiration (ET) process. The main objectives of this study is to compare three GR configurations on the ET flux and the efficacy of GR as potential urban heat island (UHI) reduction methods to make cities more resilient against UHI. GRs are instrumented in order to measure thermal, hydrological are climatic variables. All measurements are done over one year. Our work focused on three methods: i) ET is measured by an ET chamber, developed by the Cerema,

ii) ET is obtained from the residual calculation of the hydrological balance, iii) a thermal balance is solved to calculate ET.

Results show that hourly ET measurements give a good estimation. During summer, ET values are up to 250W/m² while it is less than 10W/m² in autumn. Added to this, the comparison between the measurements of ET and the water balance exhibit a certain consistency. The values of evapotranspiration are strongly influenced by the LAI, albedo and emissivity of the vegetation. The local climate also affects ET.

This study highlights the ability of GRs to participate in urban comfort at the building-scale and to mitigate UHI at urban scale.

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Offsetting carbon emission: estimating the contribution of urban green infrastructure in major Chinese cities

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Rapid urbanization and industrialization in China urge the search for integrated strategies to mitigate and adapt to climate change, which not only limit to traditional infrastructure sectors, but also cover urban green infrastructure, because plants and soils function as carbon sinks through biotic sequestration. Based on empirical data from the literature, the role of urban green infrastructure in offsetting carbon emission from fossil fuel consumption in major Chinese cities has been evaluated. Collectively, only 0.26% of the carbon emissions from fossil fuel combustion can be offset. Nevertheless, the dominance of young vegetation stands in Chinese urban green infrastructure suggests this small carbon sequestration efficiency could become substantial in the near future, given that appropriate policies and management practices are adopted to promote urban green infrastructure for climate change mitigation and adaptation.

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How effective are our urban trees in reducing urban heat?

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The overall potential of urban greenspaces for moderating the urban heat island effect is well known. However, due to the high heterogeneity of the urban environment, considerable uncertainty still exists at microscales concerning the magnitude, pattern and the process of microclimatic regulation through urban greening. In particular, there is still a lack of knowle-dge how the cooling effect of urban trees at different sites relates to the physical character of urban open spaces and their microclimatic conditions. Therefore, we compared the cooling effect of Tilia cordata at two contrasting street canyons in Munich, Germany. Results showed that tree shading can cool hard surfaces by 15-20 °C and reduce radiant temperatures by 5-7ºC thus improving human comfort; meanwhile transpiration can absorb up to 50% of the energy from incoming solar radiation. Moreover, within canopy temperature difference can peak to 3-4 ºC and reduce air temperatures underneath by 1 ºC and coupled well with water flux over a spatial and temporal scale. Thus have direct implications for the radiation energy balance of urban micro-climates. Trees grown at the open green square (OGS) showed 30% higher transpiration at mid-day compared to the trees at circular paved square (CPS), hence higher cooling effect (2.3 kW tree−1 at OGS compared to 1.9 kW tree−1 at CPS). This implies that urban areas with majority of its tree plantings in open green squares will be able to reduce the effect of ground heat storage and increase boundary layer cooling much faster compared to those planted in narrow paved squares. The study greatly improved our knowledge of the biophysical control of the whole tree transpiration hence cooling spatially and temporally in the urban environment to be used in climate models.

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SESSION 3
GI for climate regulation and climate change resilience

POSTER

The role of the individual tree in modifying microclimate: an observational study from Melbourne, Australia

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Urban trees are located within an extremely heterogeneous landscape that both influences and is influenced by the urban climate in which they reside. Tree cooling effects that are critical for improving human thermal comfort and health outcomes in extreme heat events, depend on physical and physiological tree characteristics and the location of trees within the urban environment. Urban trees may occur as isolated individuals, as street trees, or as relatively small areas of 'savanna' woodland or forest. Our group has been working across each of these GI configurations but in this presentation we focus on some detailed work undertaken on the microclimate and tree water use of an isolated tree in inner Melbourne.

Measurements of the radiation budget were made above, below, and beside the tree canopy during late summer (February–March 2014), along with observations of tree water use using sap flow sensors. In addition, a detailed cross-sectional array of 35 air temperature (Ta) sensors was established to observe microscale temperature variations within and surrounding the tree. Radiative differences below and beside the tree were critical in driving Ta differences, where peak daytime average Ta (15:00-17:00) below the tree was 0.2 °C cooler than upwind. Under heatwave conditions Ta cooling reached as high as 1.2 °C when the tree canopy served to block advected warm air, both lowering Ta below the canopy and increasing Ta on the windward side. Tree water use was consistently high, reaching over 500 L d-1 during a heatwave due to high evaporative demand from high vapour pressure deficits and the large radiative loading, along with a suspected continuous water supply from nearby leaking water mains.

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Temporal dynamics of thermal and hydraulic performances of green roof

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Green roofs (GRs) are generally recognised as effective media in the mitigation of water cycling and urban heat island at the urban-scale due to their passive cooling function. The performances of the GRs are strongly dependent upon intrinsic GR substrate characteristics that drive soil moisture and temperature as a function of meteorological conditions. Understanding the thermo-hydraulic processes is the key to assess the GRs abilities. Substrates properties are usually considered as constant over time whereas some recent works prove that they were submitted to an early pedogenesis (Bouzouidja et al., in press). As a consequence, GR performances are considered as sustainable, leading to an under-evaluation of the required maintenance practices. Thus, our work focused on the following issues: i) how to evaluate GR performances by monitoring water and heat transfer continuously; ii) what are the GR thermal and water performances over long periods and which evolutions can be expected as time goes on. The aim of this study is to present the performances of GR, under temperate climate, at different time scales: season and year during hot (HP) and cold period (CP). A 3 years monitoring was done by measuring water content, water outflow and temperature. The peak flow reduction has been derived over time. The GR has showed an annual retention capacity with fluctuation between 73 to 79% and a seasonal one by 72 to 95% in HP and CP respectively. Also, the daily maximum temperature difference between GR and non-vegetated roof has increased by 2.9°C during HP and 6.3°C in CP. This study highlights the ability of GRs in the mitigation of water and temperature variations at the building-scale. The later can be used to support detailed analysis and diagnosis of the GRs behaviour.

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To reduce the negative impacts of climate change a solution for management of landscapes: Water Retention

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The objective of the study is increasing the resilience of cities to extraordinary weather events expected by increasing capacity of climate change, while developing cooperation between Turkey and the EU in the context of adaptation to climate change and to create an environment of knowledge and experience sharing that encourages civil society dialogue. At the beginning of the problems that Turkey will face in the process of climate change are, changing in the precipitation regime, increasing in drought and decreasing in water resources. In the management of landscapes, it is possible to propose solutions that can meet the water needs of different areas by storing rainwater in urban and rural areas with the rain harvest which is sensitive to climate change. It is important because on the management of water retention landscapes the local governments and non-governmental organizations (NGO'S, etc.) in the vulnerability of their work together. Among the findings of the study; to demonstrate the feasibility of water retention methods in Turkey with the analysis of best practice examples in Europe and applicate water retention in urban parks. Study results are; implementation of rain harvesting method, to urban parks, capacity building in local governments and NGOs, preparation of guideline on adaptation to climate change and activities in the context of awareness. To create a sustainable, future-toughened city, transferring urban ecology studies into practice is the most important opportunity offered by study.

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Urban Heat Islands as a result of Urbanization: Example of Trabzon

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In our present time, fluctuations of climatic changes caused by environmental and atmospheric pollution due to technological developments adversely affect the life and human health. Especially unplanned construction, and extinction of green spaces as a result of it lead to such ecological problems as air, water and noise pollution. Climatic changes taking place in urban and accompanying rural areas are called "urban heat islands". Urban heat islands emerge due to the fact that human beings reshape the cities according to their needs and change the natural structure of the land. Therefore, new planning strategies need to be developed in order to minimize the negative effect on human beings living in urban areas.

This study has been carried out in 2016 so as to reveal the change of the urban climate of Trabzon, which has been suffering from rapid population growth and subsequent housing beginning from 2000. Urban heat islands have emerged in the city center especially in the recent years because of the temperature differences throughout the day in avenues and streets surrounded by high buildings, and decreasing amount of green spaces. In the scope of the current study, temperature differences experienced in the city of Trabzon in parallel with changing use of land and urban heat islands were detected. Temperature differences of 2 squares (Meydan Park and Atapark), which have different surface temperatures depending on their own locations and intensity of utilization, were determined through meteorological measurements. In the conclusion part, suggestions were made in order to decrease the impact of urban heat islands and pollution in respect to landscape architecture.

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Proposing poikilohydric green-roofs for the Mediterranean climate

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Green roofs are widely used because they increase the services provided to the environment in urban areas. They allow attenuation of flood effect, since they increase the retention time of rainwater; contribute to the thermal regulation of buildings by reducing the urban heat island effect, also mitigating heat loss during the winter; contribute to biodiversity; increase carbon sequestration, improving air quality; improve the soundproofing of buildings; increase the durability of roofs and the lag spread of potential fires. However, its use in the Mediterranean climate requires the use of irrigation since the traditional plant based roof cannot sustain summer drought without watering. In this work we propose to use a group of poikilohydric organisms in green-roofs adapted to Mediterranean climate to avoid irrigation; water limitation and climate change will lead to an even more severe water scarcity during summer. Poikilohydric plants can equilibrate with the relative humidity of the air during drought periods, but exhibiting complete physiological recovery upon rehydration. The poikilohydric habit is found in both cryptogamic autotrophs such as algae, lichens, mosses, and ferns, and a few vascular plant taxa such as the pteridophytes and lycophytes. Nonvascular cryptogams, particularly lichens and mosses, form the majority of species and biomass exhibiting poikilohydry within desert regions of the world. In this work we will discuss the potential and limitations of using poikilohydric plants in green-roofs as a way to be more sustainable in urban areas. As climate change will also lead to higher temperatures and erratic precipitation events in the temperate climates, these regions will also benefit from the resulting outcomes.

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Urbanization and Global Carbon Cycle

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Urban areas account for more than 70% of CO2 emissions from burning fossil fuels. Urban expansion in tropics is responsible for 5% of the annual emissions from land use change. Here I show that the effect of urbanization on the global carbon cycle extends beyond these emissions. I quantify the contribution of urbanization to the major carbon fluxes and pools globally and identify gaps crucial for predicting the evolution of the carbon cycle in the future. Urban residents currently control ~22 (12-40) % of the land carbon uptake (112 PgC/yr) and ~24 (15-39) % of the carbon emissions (117 PgC/yr) from land globally. Urbanization resulted in the creation of new carbon pools on land such as buildings (~6.7 PgC) and landfills (~30 PgC). Together these pools store 1.6 (±0.3) % of the total vegetation and soil carbon pools globally. The creation and maintenance of these new pools has been associated with high emissions of CO2, which are currently better understood than the processes associated with the dynamics of these pools and accompanying uptake of carbon. Predictions of the future trajectories of the global carbon cycle will require a much better understanding of how urban development affects the carbon cycle over the long term.

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How does drought tolerance influence ecosystem services related to biomass and transpiration?

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Urbanisation worldwide and the impacts of climate change raised awareness of urban forest ecosystem services (ESS). The regulation of the urban microclimate is one of these services, since trees have the potential to reduce urban heat loads by providing shade and transpiring water. Simultaneously, it has been suggested that trees from dry habitats should be used to cope with the increasing risks of drought under climate change in Central Europe. The underlying properties, which enable plants from dry habitats to reduce dependence on the environment however, are assumed to come at the expense of biomass production and water loss.

In the potentially conflicted area between drought tolerance and ESS we compared basal area increment (BAI), sap-flux density (Js) and total sap flow (SF), seasonal water-use efficiency (BAI/total SF) and leaf area density (LAD) of four commonly planted native species or varieties (group C: Acer platanoides, Carpinus betulus 'Fastigiata', Quercus robur, Tilia cordata 'Greenspire') and four species/varieties originating from more dry habitats (group D: Acer campestre, Ostrya carpinifolia, Quercus cerris, Tilia tomentosa 'Brabant'). The measurement campaign took place in the municipal nursery of Munich in the summer months in 2016.

Contrary to expectations, the group of drought tolerant species showed significantly higher rates of daily SF, 2.5 times higher values of Jsmax and almost twice the relative BAI in comparison to group C. Additionally, response of water use by group D to weather conditions was less pronounced. The results suggest that drought tolerance does not necessarily have to come at the expense of ESS, which is one further argument to expand the current selection of urban tree species towards drought tolerant species.

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The effects of tree shading and ground surface characteristics on human thermal stress in urban spaces of Florence

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This study evaluates human thermal comfort in different urban settings in Florence, using two thermal indices. The Index of Thermal Stress (ITS) is based on measured radiation fluxes for computation of the full energy balance between the human body and the environment, and the Universal Thermal Climate Index (UTCI), used here as a comparative index, is based on the mean radiant temperature (Tmrt). Field data collected during summer in a series of open spaces in the largest park of Florence included air temperature, global radiation, relative humidity, wind speed and albedo. In addition, ground surface temperature was measured for the calculation of long-wave radiation fluxes in ITS and black-globe thermometer measurements were made for the estimation of Tmrt in UTCI. ITS and UTCI were evaluated over exposed gravel, asphalt and grass as well as tree-shaded paving in order to investigate the effect of these different surface materials and levels of solar exposure on pedestrian thermal stress and sensation.

Initial findings indicate clear differences in thermal stress induced by the characteristics of each landscape treatment. According to ITS, a pedestrian in the unshaded gravel area would experience the most stressful conditions, reaching the highest level of thermal sensation ("very hot") in the early afternoon, while a person standing on the unshaded asphalt paving would be exposed to slightly lower thermal stress (with a "hot" sensation during most daytime hours). This distinction highlights the effect of reflected solar radiation on the body from the higher-albedo gravel surface, which more than compensates for the higher surface temperature and long-wave radiation emitted from the asphalt. The low surface temperature of the transpiring grass lawn, meanwhile, affords conditions defined as "hot" for only a short time in the afternoon, with most daytime hours characterized as "warm." The most dramatic reduction in thermal stress, however, occurs in the area shaded by trees: here a pedestrian would be exposed to thermal conditions defined as "comfortable" for nearly all hours of the day.

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Effects of planting sites on growth and services of inner-urban small leaved lime Tilia cordata Mill.

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The poor growth conditions of urban trees (e.g. highly paved, compacted sites, high soil temperatures, less water availability) affect tree vitality tremendously. Albeit decreased growth, early senescence and tree death can be expected as a result of those detrimental conditions, the effects of different planting sites in terms of degree of paving, water availability, building density on urban tree growth have rarely been quantified. Therefore, this study analyzed the intra- and interannual growth patterns of the common urban tree species Tilia cordata Mill. during the extremely hot and dry summer of 2015 at two contrasting squares in the city center of Munich, Southern Germany: a highly paved public square (CPS) and a more open, greener square (OGS). Further, a drought year analysis was conducted to ascertain whether different site conditions affect drought resistance and recovery. We found highly different tree structures and growth patterns of the analyzed trees at both sites, which was mainly influenced by tree age and distinct site conditions. The growth course over the summer was varying at both sites, while the trees at OGS grew from July until mid of August up to 2.5 mm, the trees at CPS only grew 0.4 mm in diameter. Moreover, the drought year analysis revealed significant growth reductions occurring in the consecutive years after a drought. Due to the anisohydric water stress response of T. cordata, this species can sustain growth and evaporative cooling even during drought. However, this strategy results in substantial growth decreases afterwards, in particular at stressful sites like CPS. Therefore for sustainable urban tree management, species with a better balance of growth, transpiration and evaporative cooling are more suitable for future urban plantings.

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Are you hot enough to cool yourself under a tree? Correlation between urban heat island and urban green infrastructure at European scale

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Urban heat islands (UHI) are one of the most evident effects of climate changing in cities. They impact on social equity, urban ecosystem and well-being (Schwarz et al., 2012; Maimaitiyiming et al., 2014). Urban green infrastructure (UGI) effects UHI development by reducing air temperature and improving the microclimate (Dimoundi et al., 2003).

Numerous studies identify the influence of various parameters of green areas in the selected town on the UHI's intensity or size. Usually they are focused on size, shape of green areas and vegetation composition, mainly in urban parks. However, there is a lack of studies that would address a larger area such as Europe and would connect UHI's intensity and size with UGI and planning policies in different planning families in Europe (Davies, 2016). UGI components are not equally distributed across Europe regarding share, land use category and pattern and sometimes are the result of planning tradition. Primary goal of research is to identify interrelationships between UHI magnitude and the UGI extent, shape and distribution on European scale.

UHI for European cities from Urban Audit (EC, 2016) are defined as area with land surface temperature (LST) higher than the mean temperature plus one standard deviation (Zhang and Wang, 2008). LST data source is EuroLST BIOCLIM raster dataset derived from reconstructed MODIS LST at 250m pixel resolution by Fondazione Edmund Mach (2015). Corine Land Cover (EEA, 2016) provides data for land use statistics.

Understanding the correlation of UGI characteristics on UHI in European cities will help urban planners and politics in the development of UGI for climate change mitigation.

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SESSION 4
Biodiversity and ecological implications of GI

ORAL

Keynote Speaker
A SETS perspective on green infrastructure and its services

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Urban systems are complex, non-equilibrium systems best conceived as social-ecological-technological systems (SETS). A SETS framing integrates three domains: social/equity, environmental, and engineering/technology issues. It opens up the possibility of envisioning new, more flexible, more resilient solutions to challenges associated with global environmental change. For example, extreme events like coastal and urban flooding in many cities expose the impacts of and vulnerability to extreme events that demand a new approach. Social-ecological systems and socially sensitive engineering approaches that fail to incorporate the third dimension may reduce resilience to climate-related disaster.

Green infrastructure is often touted as a solution to urban flooding challenges that can increase resilience. We identify solutions across a spectrum of gray to green, including hybrid, infrastructures that vary in their economical feasibility, effectiveness for the targeted service, distributive justice of benefits provided, and multifunctionality. The infrastructure of the future must leverage ecosystem services, improve social well being, and exploit new technologies in ways that benefit all segments of urban populations and are appropriate to the particular urban contexts. Contexts are defined not only by the biophysical environment but also by culture and institutions of each place. The SETS conceptual framework is being applied in ten diverse western hemisphere cities to co-develop, with city practitioners, visions of resilient SETS infrastructure for an uncertain future.

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Biodiversity-based and ecosystem functions-aware spatial prioritization of an Urban Green Infrastructure

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Methods in conservation biology, such as spatial conservation prioritization (SCP), allow the focal landscape, e.g. a city, to be examined as a whole. Thus, they can be used as a part of land-use planning that is sensitive to biodiversity and ecosystems. In many cases, SCP analyses and urban conservation plans are based on sets of individual species and/or biotopes, which can be seen as a limited representation of biodiversity. Rather than focusing on rare endangered species or biotopes alone, focus should in the context of urban green infrastructure be on the resilience of urban biodiversity and its ecological functions and, ultimately, on the human well-being they maintain.

Here we introduce a city-scale SCP approach to identify the most important green infrastructure sites for the resilience of urban biodiversity and diversity of ecological functions. Thus, our approach can be used as a robust proxy for ecosystem services provisioning as well. First, the focal green infrastructure is classified into urban biotopes. Next, the biotopes are evaluated (here, by local taxonomic experts) in terms of how they support different taxonomic groups' species richness, richness of specialist species, biomass, abundance, evenness, uniqueness, and regional representativeness; factors, that function as the basis for resilient and diverse urban ecological communities and ecosystem functions. Finally, the expert information is translated into spatial form and prioritized with a SCP analysis, here using the Zonation software. Different functional roles of taxonomic groups are accounted for in the weighting scheme of the SCP process. The approach is demonstrated with a case study from the Helsinki Metropolitan Region, Finland.

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Natural Capital in the City

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What trees shall the City plant for the future?" That was the question posed by the City and one that could only be answered in part. The features and potential dimensions of each tree were known, their relative tolerance of growing conditions were known, their landscape qualities were known. But which of the trees would provide home and support to the most biodiversity? The benefit to citizens of urban biodiversity is now well known so, with limited space for trees, how can we achieve the known benefits and maximise biodiversity?

That was the conundrum for City, the 'ultra-urban' core of London where urban street trees were the focus of the study. Using established surveying techniques to record Recognisable Taxonomic Units the study provided a rapid, first picture of the support of biodiversity.

The results were revealing. Aside from arthropods all other groups were depauperate. Arthropods provided a substantial data set for analysis and demonstrated variation between tree species in the support of this group.

There were good performers and there were bad performers. London plane (Platanus x hispanica) supported the least and Hornbeam (Carpinus betulus) supported the most. Native tree species, on the whole, performed best but some non-native species were also good performers.

Further studies are required to build a comprehensive picture but this pilot reveals, amongst other things:

1. There are marked differences between tree species in urban areas in the support of biodiversity
2. Tree selection needs to be mindful of the support of biodiversity to ensure human wellbeing
3. An indication that trees may sustain biodiversity in the face of increased temperatures.

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Causes, mechanisms, filters and feedbacks: a successional model for predicting vegetation dynamics and community assembly on green roofs over the long term

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In circumstances where ground-level green infrastructure (GI) is not feasible, extensive green roofs (EGRs) are versatile nature-based solutions that deliver numerous ecosystem services. Being protected from human disturbance by their elevation, EGRs can support certain forms of biodiversity and ecological processes better than other forms of urban GI. Variations in species composition and abundance from a sample of nine unmanaged EGRs were investigated two to three decades after installation to evaluate floristic change over time. With reference to CSR theory all species, both initial and current, were allocated adaptive life strategies (competitor, stress-tolerator, ruderal). This revealed successional trajectories in which the vegetation shifted from initially diverse assemblages towards flora dominated by stress-tolerators and stress-tolerant ruderals. To link these observations with current developments in succession theory, we present a model that predicts vegetation dynamics and community assembly for EGRs. By integrating general causes, specific mechanisms, ecological filters and feedbacks with reference to empirical data, our model suggests that the biodiversity supported by these systems declines with time. By identifying the main factors of influence, the model helps to clarify how these systems could more effectively support biodiversity and ecological functions. This model may be relevant to other GI applications defined by naturalistic plantings that lack contact with natural soils or bedrock. Lastly, this model may serve trans-disciplinary efforts seeking to maximise urban ecosystem services, particularly by informing the functional design of low maintenance, diverse, attractive, and resilient GI installations.

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Combining biodiversity conservation with ecosystem services provision in Urban Green Infrastructure Planning: the case of Rome

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The EU Biodiversity Strategy aims at halting the loss of biodiversity and ecosystem services (ES) by 2020 and, especially through Target 2, it promotes maintenance and enhancement of ES as well as restoration of at least 15% of degraded ecosystems by creating green infrastructure (GI). Although the GI tool is closely related to biodiversity targets, some doubts have recently arisen as regards the ability of currently developed projects to provide beneficial effects for both human societies and the ecological systems that host them. In keeping with the implementation of the EU Strategy in Italy, we present two GI projects for the metropolitan area of Rome explicitly developed for combining the supply of ES with the restoration of degraded ecosystems and the enhancement of ecological connectivity. According to the specific requirements of a metropolitan city, we attuned at a proper scale for intervention: i) the criteria for setting biodiversity priorities (e.g. persistence, extent, and degree of fragmentation of natural and semi-natural ecosystems); ii) the understanding and spatial recognition of key demands for ES (e.g. improving air quality, halting land degradation, promoting traditional landscape values); and iii) the opportunity of integrating GI into existing policy and planning tools (e.g. master plan ecological network and regional rural development plan). By means of the estimate of both the environmental and socio-economic expected benefits, the proposals were adopted as pilot case studies for promoting at the national level the actual inclusion of GI into land development planning and for encouraging investments into 'green' rather than 'grey' solutions against pressures that affect environment and human well-being in cities and their hinterland.

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Studying diversity and heavy metal absorption properties of urban tree species used in environmental pollution control in Yerevan (Armenia)

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This long-term monitoring implemented between 2007 and 2015 was designed to study diversity and heavy metal absorption properties of street and park tree species in Yerevan – Armenia's capital.

The obtained data have indicated that the assortment of park trees includes some 50 species, the most widespread being Acer negundo L. (19.3%), Ulmus minor L. (12.6%), Robinia pseudoacacia L. (10.3%), Fraxinus excelsior L. (9.3%) and Platanus orientalis L. (8%), that of street trees – some 30 species dominated by Fraxinus excelsior L. (22.8%), Ulmus minor L. (16.3%), Quercus robur L. (14.3%) and Platanus orientalis L. (8.9%). The number of invasive species is higher than that of indigenous both street and park species. The most widespread species throughout Yerevan is F. excelsior L.

Heavy metals are known to be priority pollutants to Yerevan. So, to study Pb, Hg, Ni, Mo, Cu, Zn, Mn, Cr, Sn, Ag absorption and accumulation properties of five most widespread species R. pseudoacacia L., P. orientalis L., F. excelsior L., Ul. minor L. and P. alba L. leaf sampling was done and heavy metal contents in the sampled leaves measured through atomic–absorption spectrometry.

The results for 2007-2011 allowed us to conclude that for the studied period dominant pollutants of tree leaves in Yerevan were Pb, Ni and Mo, whereas in 2012 – 2015 Pb concentrations were steadily decreasing and Hg was included in the list of dominant pollutants of the city environment. Metal accumulation properties were found out to be the best in R. pseudoacacia, F. excelsior and P. alba.

Results obtained for the entire period of monitoring are widely applicable and will support development of a new urban tree recovery plan for city of Yerevan.

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Impact of de-icing salts in the street greenery of Riga Latvia: a long term perspective from the research

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Street greeneries form key elements of the urban landscape throughout the world and provide invaluable societal and ecological services. However, vegetation elements such as street trees are seriously impacted by a considerable range of stress factors. For more than 10 years, we have assessed the environmental constraints and especially the effects of de-icing salts in lime trees, one of the most popular trees in cities of Central and Northern Europe such as Riga, Latvia. Different approaches in mineral nutrition, ecophysiology and morpho-anatomy have been combined in the field and in the framework of experiments in partially controlled conditions. The accumulation of de-icing salts during subsequent vegetation season, especially in foliage, was shown to be the principal stress factor affecting the street greenery in Riga. It causes the development of leaf necrosis and premature decay of young and old trees. The steady uptake of sodium and chloride contaminants appears to interfere with that of key major and minor nutrients (K, Ca, B, Mg, etc.). Within foliage, mainly the accumulation of Na and Cl ions accelerates the cell and leaf senescence, along characteristic injury gradients of increasing severity from the leaf centre to necrotic leaf rim. First indications from species and provenances trials indicate interspecific differences in salt-tolerance and may open perspectives for developing more resistant cultivars in the future. Together with improvement in our mechanistic understanding of salt effects in lime trees, we thus aim at developing applicable solutions for improving the vitality and sustainable management of street trees in urban environment of the boreo-nemoral climatic zone.

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Landscape ecology as theoretical framework for green infrastructures planning

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Landscape ecology is a branch of ecology that "study the structure, function and change in a heterogeneous land area composed of interacting ecosystems" (Forman & Godron, 1986).

The spatial scale range from few hundreds of meters to dozens of kilometers, and allows a spatial planning of green infrastructures with a proper context. In order to achieve results in biodiversity conservation and habitat restoration landscape ecology developed theories, principles and practical tools, that now may help planners.

Some examples may be provided: in particular the paradigm of ecological networks and diffuse corridor underline the need of restoration projects that increase the overall matrix quality. In Milano suburbs different restoration projects aims to develop a green infrastructure into a coherent framework.

Other examples may arise from the development of ecosystem services theory: landscape is the effective contest where ecosystem services may be evaluated and weighted. Examples from the evaluation of ecosystem services in urban and suburban parks of Milano will be provided.

Landscape ecologists may help planners during the development of green infrastructures, adding coherent principles of ecology and addressing the programs of biodiversity conservation.

Those topics will be developed into the 10th world congress of the International Association of Landscape Ecology (IALE) that will be organized by the Italian chapter of IALE (SIEP-IALE) in July 2019 in the University of Milano-Bicocca.

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Enhancing biodiversity through edible trees stewardship initiatives: Lessons from Berlin

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Even though there is growing awareness about the role of urban agriculture in the context of biodiversity and food security for cities, urban edible trees (in public spaces) still largely remains isolated as an episodic part that is not being integrated into green infrastructure.

Edible trees expose particular challenges in the urban context, for their complexity and uncertainty of placement. Yet there are initiatives, working toward the process of integrating edible trees in the urban environment.

This paper investigates top-down and bottom-up initiatives from Berlin related to urban trees and species selections. I focus attention on the role of different actors, governmental and non-governmental and their contribution to the topic. The outcome shows that even in metropolitan size cities when there is a political will it is possible to accommodate different edible plants in public spaces.

These new green infrastructure initiatives seems to change the species composition, and distribution, also the structure of urban public spaces.

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Impact of urban green areas on the biodiversity of butterflies (Insecta: Lepidoptera) in NCT of Delhi, India

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The increase of urbanization in cities has generated many fragmented and concrete lands at a rapid pace while very few areas have been recreated as green areas for the conservation of the biodiversity of local flora and fauna. Butterflies being poikilotherms respond to such environmental changes sharply with a decline in their population diversity. In the present study diversity assemblage of the butterflies were studied diurnally for different seasons.

They were compared and analysed with the changing patterns of land use and habitats.The study was conducted from January to December,2016 and presence of different species under sub-order Rhophalocera were recorded by using line transect method. The relation of butterflies with specific host plants has been observed for their food and feeding behaviour. The observation of the study showed that the significance of green patches within urban infrastructure is needed to restore the local butterfly fauna of the city. With increasing awareness among the residents it would help to improve the regional biodiversity richness of an urban area.

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Urban Biodiversity: Much more than protected nature

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Colombia's shift towards urbanization has brought deep changes in the natural ecosystems, biodiversity and ecosystem services characterizing different regions of this country. A phenomenon that has generated the loss of multiple natural land covers or wildlife species, but also a dramatic reduction in the quality of life of people living in these territories. A fact evident in pollution, water scarcity, social and environmental conflicts and poverty that has been growing in all urban areas of Colombia.

What role should play a national institute on biodiversity in the understanding and management of this phenomenon? How should this institute approach the challenge of reducing the gap between scientific knowledge, management and urban planning and decision-making in cities? How can different systems of knowledge meet in order to better understand the relationship between biodiversity and cities?

Conceptual and practical approaches that have guided the responses given by the Alexander von Humboldt Institute to these questions are presented. The results of a book published in 2015 called Naturaleza Urbana: Plataforma de Experiencias. An action-oriented research that more than a publication, represents the meeting of multiple local and regional experiences that have come together in this book to provide a toolbox that serve to manage biodiversity and ecosystem services in urban areas in Colombia. Taking this into account, the Humboldt Institute will present some of the insights and conclusions of Naturaleza Urbana, expecting contributions, proposals and questions to help us rethink the role of nature in this new urban age.

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Eau de Paris – Aqueduct revegetation in an urbanized area

*Roxane Billion-Prunier**

Eau de Paris is the biggest public water operator in France. Eau de Paris is in charge of collecting, processing and distributing drinking water for the Parisians. The company ensures the supply under all circumstances of a top-quality water from the water sources to the user tap. 550 000 m3 are delivered each day to 3 million consumers. The water sources are springs and rivers: the springs are far from Paris (up to 170 km), and the water then flows by gravity all the way to Paris in the aqueducts. The river waters are collected close to Paris on the Seine and the Marne rivers.

In the fall of 2016, Eau de Paris finalized the revegetation work of the aqueduct de la Vanne's roof.

The water bridge crosses an urbanized valley near Paris. 1060 meters long, it culminates at 38 meters above the valley. It was built at the end of the 19th century.

The aqueduct's waterproofing required a renovation. The interest of using that opportunity to create an ecological continuity was highlighted, given the connection established by the aqueduct on the territory.

It was chosen to set up a semi-intensive vegetation of grassland or dry grassland (predation, pollination, reproduction and recovery areas), based on wild flowers. It favors the ecological grinding of the territory: the green roof of the aqueduct forms a herbaceous continuity between the territories connected by the aqueduct, constituting a peaceful environment for the fauna and the flora.

This multifunctional green roof created is beneficial to biodiversity in a zone with strong ecological stakes, very urbanized, with a poor vegetation, and contributes to the fight against climate change, to the purification of rainwater and to the recovery of waste.

The green roof now covers an area of 1,600 square meters. To verify the evolution of the environment and measure the ecological benefits of the project, ecological monitoring is planned over three years.

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Multifunctional Planting Design: towards a healthy and resilient green infrastructure

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In urban environments, vegetation is constantly under a wide range of stress factors that weakens it, making it more susceptible to diseases and pests attacks. In order to achieve and maintain a healthy and effective green infrastructure, it is increasingly urgent to find

nature-based solutions to deal with this problem, as the use of pesticides is more and more censored and legally limited.

Traditionally, Landscape Architecture Planting Designs select species based on their aesthetic characteristics such as color, form and texture. Sometimes they are arranged according to their ecological preferences, but very rarely the multifunctional value of vegetation is taken into account. It is our belief that new selecting criteria based on biological control knowledge can be ultimately the answer to (re)create healthy plant communities.

The aim of this research was to contribute to solve phytosanitary problems of vegetation in urban green spaces with a planting design that includes species that attract beneficial insects by providing shelter and food. An extensive literature review provided a conjoint of species and guidelines to the planting design process which could be applied, either to reduce pest levels or to prevent future attacks.

As a practical example this planting design method was tested in the garden of the Nursing School of Porto, in Portugal, which has a mature green structure with several remarkable trees currently threatened by a strong aphids' attack.

Healthy plants are imperative to maximize green infrastructure performance and its capacity to deliver services. The inclusion of target species in urban green spaces to prevent phytosanitary problems or improve the overall phytosanitary condition can be one step ahead for the future of more resilient cities.

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Linking biodiversity and ecosystem functioning of green infrastructures - First attempts and perspectives

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Human activities influence the occurrence and the distribution of biodiversity in urban ecosystems. Investigating the link between biodiversity and ecosystem functioning (BEF) in human dominated systems allows the identification of the mechanisms behind key ecosystem services and functional resilience. Here we present first results from a large and interdisciplinary study that aims to understand the human driven determinants of biodiversity and associated ecosystem processes and services in urban areas by using gardens as model systems (www.bettergardens.ch/en).

In a first example, we show the effect of vegetation structure on pest-control by birds and demonstrate that predation rates are driven by the interaction between woody vegetation cover at garden and landscape scales. I.e., gardens with high woody vegetation cover in dense urban areas are likely to benefit from higher predation rates than other combinations of vegetation and landscape structures. This suggests that birds respond to contrasted structures of the vegetation at different spatial scales, with woody vegetated gardens acting as resource islands and thereby favouring pest control; especially in dense urbanised areas.

In a further example we link biodiversity of different soil macro-detritivores (earthworms, woodlice, millipedes) with key soil processes, such as decomposition of organic matter, soil respiration, and nutrient cycling along two independent gradients; namely garden management intensity and the degree of urbanization in the surrounding area. We found contrasting patterns of BEF relationships among taxa and ecosystem functions, which shows the importance of including human decisions when trying to understand the mechanisms behind BEF relationships in human dominated ecosystems.

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Biodiversity and quality of cultivated trees in domestic gardens of Hong Kong

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Domestic gardens, constituting an important component of the urban green infrastructure, can enrich urban biodiversity in a unique way. This study evaluated species composition, floristic diversity, amenity-ecological characteristics, habitat condition, and performance of trees in domestic gardens. The garden-city estate in urban Hong Kong has European-style detached houses built in the 1920s. The 1,501 individual trees belonged to 72 species, 61 genera and 36 families. With domination by a small cohort of popular species, they skewed heavily towards exotic species count (84.7%) and tree count (91.3%). The prominent amenity-ecological attributes were fast growth and establishment, and interesting tree form and foliage. Nonmetric Multidimensional Scaling indicated strong association between species distribution in domestic gardens and habitat-tree variables such as tree density, tree aggregation, species aggregation, lots with trees and house lots. Redundancy Analysis (RDA) showed correlation ($p<0.05$) between tree and species counts and lot frontage and garden depth. Detrended Correspondence Analysis identified 16 species with widespread moderate or severe structural damage, and 22 species with very poor or poor overall condition. RDA further found correlation ($p<0.05$) between structural damage and overall condition, and tree position and confinement type. An integrated landscape plan with appropriate incentives and technical guidance can further augment arboreal biodiversity. Management implications for conservation and planting of garden trees could be applied to south China and other cities.

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SESSION 4
Biodiversity and ecological implications of GI

POSTER

The influence of urban green space on leaf litter decomposition, C, N quantity and soil pH

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Understanding the influence of environmental conditions on different kinds of urban green space, including natural processes, is important for managing urban spaces. The aim of this study is to explore how different kinds of urban green space affects tree leaf litter decomposition, the C:N ratio and soil alkalinisation. We assessed 5 different kinds of urban green spaces using four dominant native deciduous tree species: Tilia cordata Mill., Acer platanoides L., Betula pendula Roth, and Quercus robur L. respectively in Kaunas, Lithuania. The study was carried out during 2013-2014.

The leaves of Betula pendula and Acer platanoides decayed faster in street lined green space. Quercus robur leaf litter decomposed faster in peri-urban forest. The leaf litter decomposition of Tilia cordata site was not influenced by the different kinds of green spaces. Soil pH in street greeneries was more alkaline than in urban parks. Our research results showed that the environmental processes of different types of urban green spaces are different.

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Ecophysiological characterization of green roof vegetation for urban mitigation

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The ability of green roof vegetation to mitigate greenhouse gasses and urban pollutants was evaluated. The ecophysiology and micromorphology of 16 shrubs and grasses used in the experimental green roof of BEST building in Milan were established by measuring CO2 absorption and biogenic volatile organic compound (BVOC) emission, and by the analysis of foliar micromorphology. CO2 exchanges were measured with a portable infrared gas analyser, BVOC emission with a Proton Transfer Reaction – Mass Spectrometry (PTR-MS) and the identities of the recovered compounds were confirmed by Gas Chromatography–Mass Spectrometry (GC-MS) analysis; foliar micromorphology (stomata, trichomes, waxes and ornamentations) was studied with a Scanning Electron Microscope (SEM). The structure and number of stomata permit the absorption of the greenhouse gas CO2 as well as of gaseous pollutants (CO, SO2, NOx and O3). The presence of morphological structures such as trichomes, waxes and foliar ornamentations allow leaves to retain the particulate matter. However, in urban areas the selection criteria for plant species should also take into account the capacity of vegetation to synthesize and release in the air BVOCs. In fact, when these compounds are in the atmosphere, they can contribute to the formation or removal of ozone and other pollutants through photochemical reactions, which involve nitrogen oxides. The species under study were evaluated to be overall apt for mitigation in an urban environment. BVOC emission was negligible with the only exception of Hypericum moserianum that was a medium emitter. Origanum vulgare resulted as a no emitting species but characterized by BVOC storage structures (glandular trichomes) that can release volatiles when mechanically stressed.

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Impact of urban stresses on plant growth in Liquidambar Styraciflua L.: physiological and biochemical mechanisms

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Urban greenery has well-recognized environmental, aesthetic and landscaping functions. However, plants grown in cities are subjected to a combination of stresses, reducing their usefulness. Plant responses to multiple stresses are complex, hard to predict and still not fully understood. Therefore in this study we address combined effects of moderate levels of salinity and drought on plant performance using realistic stress scenarios in urban environment.

Liquidambar styraciflua L plants were exposed to (i) drought and re-watering cycles, (ii) increased salinity and (iii) combination of those two stresses. After stress and recovery periods efficiency of photosynthetic apparatus (gas exchange, chlorophyll a fluorescence) and plants water status (transpiration rate, leaf water potential) were measured. Samples for determination of photosynthetic pigments and isoprene emission were taken as well.

Drought and salinity applied alone or in combination adversely affected plants water status and reduced photosynthesis efficiency. Negative effect was more pronounced with combined stresses, but performance of plants grown under single stresses was only slightly better, with salinity as more unfavorable. Isoprene emission was also reduced, especially in plants under salinity stress, but to a lesser extent than photosynthesis rate, and continued even if photosynthesis was severely reduced. Thus, mechanisms regulating photosynthesis and isoprene emission seem to be influenced differently by drought and salinity. Re-watering resulted in re-establishment of efficient photosynthesis and isoprene emission. Recovery from salt stress was found for photosynthetic apparatus, but not for isoprene emission.

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Responses to de-icing salt contamination in the street greenery of Riga, Latvia

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By mitigating climate extremes, reducing air and soil pollution and promoting the local biodiversity, the urban ecosystems provide invaluable ecosystem services. In cities at mid- and higher latitudes as Riga, Latvia, the street greenery is strongly affected by large quantities of de-icing salts, which causes tree dieback and replacement. In the boreo-nemoral climatic zone, lime trees (Tilia sp.) are among the most widespread ornamental trees. However, their sensitivity to de-icing salts complicates the sustainable management of street trees. The main objectives in this study were to investigate responses to de-icing salt pollution at soil, tree and ecosystem level, by characterizing the 1) salt accumulation and its effects on soil properties, 2) impact on ecophysiological and morphological traits in foliage of three lime tree species during an exposure experiments with young trees, and 3) changes in the biodiversity of arthropod communities living in the tree canopy of street trees. In tree rows, the street proximity caused an increase in Na concentration, especially within the higher soil horizons, but few changes to the other properties of mostly sandy soils. The lime tree species showed contrasted tolerance to one-year salt exposure. The higher salt concentration in foliage of street trees increased the biodiversity of arthropod communities but reduced the frequency of aphid species. Salt contamination thus has multiple effects on the street greenery: mostly the soil chemistry appeared changed and the high salt concentration in foliage altered the population structure of arthropod communities. However, the selection and plantation of more salt-tolerant lime trees appear possible and could thus provide a solution for more sustainable management of street greeneries.

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From ecological network to green infrastructure in the Italian territory: the case of Alpine Regions

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After the spreading and the inclusion of the Ecological Network (EN) paradigm within territorial planning processes, the new vision of widespread naturalness in the framework of Green Infrastructure (GI), could induce many difficulties. In fact, concerning the EN as main pillar of GI, a dual situation can be observed: on one hand the lack of a specific national law framework on this topic, on the other hand several local Administrations established specific planning regulation in order to manage the EN in their territorial planning processes.

This situation has produced a lack of homogeneity between eco-functional definition and physical EN elements (as elements of GI) in the regional planning tools. The achievement of the final goal (GI at continental scale) may be hindered by this lack of homogeneity. It's so necessary to implement the process of analysis and comparison among the different terminologies used to identify the components of EN and GI in order to identify lexical convergence. The final aim is to reach an unique technical list of elements to standardize concepts and definitions and let them available as a common language database for the different stakeholder involved in spatial planning activities from now on.

This work is a preliminary essay to contribute to the process of normalization of the regional planned ecological network legend taking in account some Italian Alpine Regions. Regional plans will be considered in order to compare/integrate the different elements in the list of potential priority components for a TEN-G (Final report Supporting the Implementation of Green Infrastructure, EC2016). The emerged list will incorporate different types of components, thus would be suitable for implementation in a various areas across the national territory.

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Nature 2000 Network in major Italian cities: a qualitative and quantitative analysis

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Natural and semi-natural heritage in urbanised contexts often includes Nature 2000 Network sites, designed for biodiversity conservation at European scale, which include Sites of Community Importance (SCIs), then designated as Special Areas of Conservation (SACs), and Special Protection Areas (SPAs). The poster analyses Nature 2000 Network in 116 Italian cities, examining in particular three indicators (data are updated at October 2015).

First indicator is the number of Nature 2000 Network sites for each Municipality: at least one site is located in 88 out of 116 Municipalities (for a total of 300 sites). In line with the national situation, SCIs are the most numerous sites: in the 88 Municipalities there are 204 SCIs, 45 SPAs and 51 SCIs/SPAs, and many are included in protected areas (117 out of 300). Second indicator is the total number of habitats protected under the 92/42/CEE Directive. Moreover the more common habitat in the Municipal territory is analyzed.

According to national statistics, a predominance of forest habitats comes out, especially in the North. In many cities the most widespread habitat is of major conservation concern, but often in an inadequate state of conservation. The last indicator is the number of protected species of flora and fauna for site. A given species can be present in more than a site, showing how the territory of a given city can be important for the global conservation of that species. In analyzed sites various priority species and various examples of naturalistic interest are shown.

The analysis represents only a small part of the rich biodiversity heritage located in examined sites, but underlines the important role of these sites for biodiversity conservation and environmental education in highly urbanised contexts.

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Variability among lignicolous Basidiomycota fungi that affect urban trees in Lisbon

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Trees are essential elements in modern cities, providing important benefits. Nonetheless they are submitted to a serious of abiotic and biotic constraints. Decay fungi can cause a tree to be hazardous and are a major concern in the supervision of urban areas. Timely detection and identification of these fungi are essential to define appropriate management strategies.

In the present study, samples of decay fungi were collected from several species of urban trees in Lisbon and identified based on macroscopic features of the basidiomata, cultural and molecular characterization. Nucleotidic sequences of the ITS and LSU (28S) regions of rDNA were obtained in order to analyze the genetic variability among isolates belonging to the most representative species.

Fifty-four basidiomata were collected and 43% were identified as Inonotus rickii, followed by 22% of Phellinus spp. and 17% of Ganoderma spp. These fungi affected mainly hackberry, plane, lime and ash trees. Regarding the isolates of I. rickii, the phylogenetic analysis of both rDNA regions confirmed the identification previously made and revealed a low intraspecific genetic variability. Among the Ganoderma spp. isolates, G. australe and G. resinaceum were confirmed, and the genetic variability found for both regions was low as well. For the genus Phellinus the analysis of the ITS and LSU regions allowed to identify isolates previously allocated to P. pomaceus and to P. punctatus as belonging to the complex Fomitiporia mediterranea/F. pseudopunctata.

The analysis of both the ITS and LSU regions enabled the identification of the main basidiomicetes species causing decay in urban trees, providing an important decision tool for the sustainable management of green infrastructures.

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Bird species richness in Italian parks and surrounding built-up areas

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The richness of all bird species and conservation concern species were investigated in 40 parks and their surrounding built-up areas of 27 Italian towns. Data were obtained from published urban atlases of breeding birds (25 parks) and additional personal communication of Italian ornithologists (15 parks). We define species of conservation concern as those included in the Annex I of EC Directive 09/147/CE and/or in the categories 1–3 of the Species of European Conservation Concern (SPEC). Total species richness and species of conservation concern were compared between the parks and the surrounding built-up areas (500 m around the parks). The role of park features such as size and distance from the centre was investigated for these two parameters. The analysis was repeated for single bird species of conservation concern and for a selection of functional groups of these species. According to homogenising theories of urban areas, no significant differences were observed between parks and surrounding built-up areas for the investigated parameters of breeding bird community and for the frequency of single species. Woodland bird species and woodpeckers of conservation concern were the only groups more diffuse in parks. However, the fact that we did not find significant effects for the group of tree-nesting species and for most woodland bird species might be due to the presence of tree rows and green areas in the urban matrix around the parks that reduce fragmentation effects. As expected, the frequency of building-nesting and aerial feeders was higher in built areas. Variables related to town size and distance from the centre appeared to produce higher effects than park size on species frequencies in parks.

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Comparison of alien tree species communities in urban greeneries of Kaunas surroundings

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In this study we examine the species composition of neophyte communities of Thuja occidentalis, Pinus mugo, Larix sibirica, Larix x eurolepis, Fraxinus americana, Quercus rubra, Robinia pseudoacacia, Sorbus intermedia and Aesculus hippocastanus and compare site conditions after 50 years grow in the urban environment of Kaunas, Lithuania. 27 plots of 9 tree species communities were selected. Within each plot, all vascular plant species were recorded and abundance was estimated in June – August 2016. In each tree species site, composite soil samples of the 0–10 cm mineral topsoil, for the estimation of pH were collected at nine systematically distributed points. For the vegetation data analyses canonical correspondence analysis was used. An indicator species analysis was carried out in order to determine indicator species for the groups. The relationship between the soil pH parameters was assessed by principal component analysis. The results showed that the soil pH differ significantly. The more alkaline (pH(CaCl2) 7,28 - neutral) soil was in Robinia pseudoacacia, more acid (pH(CaCl2) 5,29) – in Larix x eurolepis sites. The shrub layer was more developed in Larix x eurolepis communities. The herb layer was less developed in Thuja occidentalis communities.

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In the case of KTÜ Campus, The Importance of Urban Green Areas in terms of Bird Species

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Urban open green areas offer many opportunities for urban people. Green areas with a large number of contributions in ecological, economic and cultural terms can also be a living environment for other living things like humans. Birds are important animals that benefit from urban open green areas.

This statement belongs to a study carried out on the example of the Black Sea Technical University Campus. Apart from general information about bird species throughout the campus, different types of bird photos taken at different times within the boundaries of the area visible from the window of the room of a teaching member were presented in the study. As a result, the inventory of the species of birds in these photographs has been removed. The possibilities for the different types of birds in green areas have been discussed. A total of 10 different bird species have been identified and photographed over the same small area over a period of one year.The number of bird species detected in this small area has also been a predictor for the campus.

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SESSION 5
Health focused GI – Enabling healthy and active lives

ORAL

Keynote Speaker
The science of restorative experience: Understanding a general pathway for health benefits of natural environments

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How can green infrastructure enable healthy and active lives? This question directs attention to the possible pathways through which features of urban nature can come to be beneficial. Scientists have to date mainly focused on particular pathways in line with disciplinary conventions. For example, environmental epidemiologists have focused on how urban greenery might mitigate exposures to noise and air pollution, and health promotion specialists have focused on how nearby parks and green spaces might attract residents to engage in physical activity. Yet researchers increasingly appreciate that multiple processes are likely to work simultaneously; they are intertwined, and work together in ways as yet little studied. In this presentation, I will discuss psychological restoration as a pathway through which diverse types of urban nature - encountered when in parks, walking along streets, looking out from a window or visiting a private garden – can work as a general pathway, relevant for diverse mental and physical health outcomes in which stress has been implicated as a causal factor. Reflecting my background in environmental psychology, I will first discuss the restoration pathway of itself, with a view to the different processes it encompasses, notably attention restoration and psychophysiological stress reduction, and to the common components of environmental experiences in which those processes can operate. I will then discuss how restorative experience may relate to other pathways between urban nature and health, including mitigation of exposures to noise and air pollution and the promotion of physical activity. The discussion will indicate potential problems with a focus on individual pathways in the effort to understand how health benefits of green infrastructure arise, but on a positive note it will also show how health can be influenced by multiple processes that are sensitive to a diverse green infrastructure measures.

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Nearby green space and human health

E. Dinand Ekkel, Sjerp de Vries*

There is a growing recognition in the scientific literature that contact with nature has the potential to positively contribute to human health and well-being. For the purpose of developing healthy urban neighbourhoods, this raises the question of how to translate the scientific evidence into practical guidelines. Contact with nature presupposes access. This presentation gives an overview of quantitative and qualitative aspects of access to nature and empirical studies addressing these aspects in relation to health. Comparing results across studies proved to be difficult. Access to nature was measured in a variety of ways and the accessibility metric that was chosen was often not problematized. However, we found a few studies who compared different types of accessibility metrics. These studies suggest that cumulative opportunities indicators are more consistently positively related to health than residential proximity ones. In contrast to residential proximity indicators, cumulative opportunities indicators take all the green space within a certain distance into account, rather than only the nearest green area of a certain minimum size. We argue that a more function-oriented approach to access and accessibility metrics is needed. How precisely is contact with nature expected to positively affect health and what type of nature and additional qualities are likely to be relevant in this regard? Answers to such questions will help to develop more suitable accessibility metrics, on which more effective guidelines for urban planning may be based.

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Development of green infrastructure and quality of urban life: a case study

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The quality of life and the quality of the residential environment in the urban space are, to a significant degree, conditioned by the GI. This results from the growing ecological awareness of the society and the greater importance attached to the quality of the surrounding environment. Such an approach influences the city's image and its perception with respect to the quality of life and the population's decisions as far as the place of residence is concerned. Bearing this in mind, local government authorities develop investments in the area of GI.

Olsztyn is an example of a city with exceptionally rich assets of natural environment, located in the cleanest region of Poland. The city develops in line with the "Olsztyn: the Garden City" slogan, which finds its reflection in the spatial and investment policy pursued by the local government authorities. The objective of the article is to compare the results of a public opinion poll among city residents with respect to the quality of life with changes in the natural environment resources and investments in the area of recreational infrastructure. The study covers the period from 2000 to 2016.

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Nearby nature and mental health: green and blue space as possible substitutes

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Up till now, research on the availability of nature in residential environments and the well-being of their inhabitants has been predominantly oriented towards vegetation in the form of green space. On theoretical grounds it can be argued that contact with water, or blue space, has similar psychological effects as that with green space, by way of stress reduction and restoration from mental fatigue. If this is indeed the case, then blue space and green space may be considered substitutes for each other in this respect. As a consequence, looking only at one (green space) and ignoring the other (blue space) may underestimate its effect on mental health, depending on the extent that they are negatively interrelated. Based on a general population survey (n = 6621), this idea was put to a test.

The predictive value of the amount of green space and that of the amount of blue space within 1 km from one's home for self-reported health (MHI-5) was assessed, controlling for socio-demographic and -economic confounders, as well as the level of urbanity. Multi-level regression analyses showed that when green space and blue space are separately introduced only blue space has significant predictive value. When green space as well as blue space is included in the regression model, both have a significant effect and parameter values become more positive. The contribution of blue space was larger than that of green space. A similar pattern was observed for anxiety disorder, as assessed by a diagnostic interview (CIDI). For mood disorder, only blue space had a significant predictive value. Thereby our results suggest that blue space in itself deserves more systematic research attention and in future research it is advisable to look at both natural components simultaneously.

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How eye-catching are natural features when walking through a park? Eye-tracking responses to videos of walks

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Since the 1960s researchers have developed a range of techniques for evaluating landscape preference. As this research has progressed the methods for evaluation have become more refined and a variety of meta-theories to explain landscape appreciation have been developed. In parallel with this trend, eye-tracking technology has become cheaper, more mobile and more accurate, heralding a new era of big data capture and potentially allowing assumptions about landscape preference to be tested. In this project our objective was to capitalise on the increasing mobility, sophistication and cheapness of eye-tracking technology to examine its utility in analysing landscape preference. In the following we describe how we eye-tracked 35 participants as they viewed pre-filmed walks through two different parks in the urban center of Melbourne, Australia. We show how differently participants viewed the objects in the parks. We also show how, relative to the time and space that objects occupy, participants overwhelmingly dwelt on and returned to man-made objects such as lamp-posts or edge features on the path such as rocks. We contrast these findings with the participants' claims about the reasons for liking the parks.

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Healthy benefits of UGI – does diversity matter? Biocultural diversity of European urban parks

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Urban green infrastructure (UGI) provides multiple benefits for citizens and the environment. Green spaces in cities contributes to more sustainable and healthy cities. However, UGI is not ideologically neutral spaces, nor physically homogeneous, providing benefits and satisfaction equally for residents. Utilization and values of UGI differs for ecological, cultural, social, political and economic reasons. To make urban green planning socially successful and to really employ UGI to achieve more of the often emphasized social cohesion and justice, it is crucial that urban planners and city mangers understand if and how green spaces are accessible and meaningful for different cultural and social groups, and what kind of values or close bonds they have towards green spaces based on their uses. The EU FP7 project Green Surge aims are to identify, develop and test ways of connecting green spaces, biodiversity, people and the green economy, in order to meet major urban challenges related to land use conflicts, climate change adaptation, demographic changes, and human health and wellbeing. The project have applied an innovative biocultural diversity (BCD) approach to facilitate socio-ecological integration and to assess how residents with different cultural backgrounds and socio-economic situations value and use of UGI across European cities. We studied BCD on urban parks in four cities in Europe (Berlin, Helsinki, Leipzig, Lisbon). We illustrate how the BCD concept can be applied as a methodological tool to enhance socio-ecological resilience and sustainability of cities and discuss how BCD assessment can increase our understanding on healthy UGI that are more than just green.

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A systematic review of the evidence on the association between green spaces and cognition

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Health benefits of exposure to natural environments including green spaces have been shown in an accumulating body of evidence. Currently, green space has been associated with improved mental health and self-perceived general health, and reduced morbidity and mortality. Through the proposed pathways for these associations, namely increased physical activity and social interaction, improved attentional capacity, reduced stress, and decreased exposure to air pollution, noise and heat, green spaces could also be associated to cognitive functioning. The aim of the present study was to systematically review the available observational evidence on the association between long-term exposure to green space and cognition over the life course.

We searched PubMed and Scopus using a combination of green space and cognition keywords. Original research articles of observational studies on the association between green space exposure and cognition were collected. The quality of available studies was assessed using available frameworks.

The review identified thirteen studies meeting the selection criteria. Considering the limited number of available studies, and as most were of poor or fair quality, the existing evidence on the association between green spaces and cognition can be considered as inadequate; however, it is suggestive for beneficial associations between such an exposure and cognitive development in childhood and cognitive function in adulthood. Results for an association with cognitive decline in older adults have been inconsistent. The findings of the articles included in this review call for further investigations.

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Lifelong exposure to green space and attentional development: a prospective birth cohort study

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Introduction: Natural environments including green spaces are thought to exert beneficial impacts on brain development; however, the available evidence on such impacts is still very scarce. We aimed to evaluate the association between lifelong exposure to residential surrounding greenness and cognitive development during preschool and early primary school years.

Methods: A longitudinal study based on data from a well-established multi-centre population-based birth cohort in Sabadell and Valencia (Spain) following participants from pregnancy (2003-2006) till 7 years of age (2012-13). Satellite-derived normalized difference vegetation index (NDVI) was used to quantify surrounding greenness (100m, 300m, and 500m buffers) of participants' residential addresses at birth and at 4 and 7 years of age. Attentional function was assessed using Kiddie-Continuous Performance Test (K-CPT) at age 4 (N=888) and Attention Network Task (ANT) at age 7 (N=978). Mixed effects linear and negative binomial models with cohort random effect were developed to quantify the association between greenness exposure and attention adjusted for relevant covariates.

Results: Higher average residential surrounding greenness between birth and age 4 was associated with lower omission errors and lower hit reaction time standard error (HRT-SE), both indicators of inattentiveness in K-CPT. Similarly, higher average residential surrounding greenness between birth and age 7 was associated with lower HRT-SE in ANT.

Conclusions: This is the first longitudinal study to report on the impact of lifelong green space exposure on cognitive development in general and attentional development in particular. It found this exposure was associated with enhanced attentiveness in preschool and primary schoolchildren.

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Relationship of green areas and visitor's health in two municipalities of the city of Belgrade

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The quality of urban areas is increasingly recognized to benefit to human health and wellbeing. Many studies suggest that there is a positive relationship between green spaces and the general health of the population, positively influencing mental well-being and cognitive function, through both physical access and usage. Anyway, there is little evidence to show whether the impacts of green spaces on health vary depending on the type of green space involved. In this paper, we analysed the relationship between quality of green areas and socio-economic and health characteristics of its visitors in two municipalities of the city of Belgrade. We conducted a survey with two hundred respondents in the municipality of Vračar and Čukarica. The purpose of the survey was to discover whether residents who live in areas with more green spaces are healthier and weather they spend more time in green areas. Using the t-test for independent samples results showed that respondents who walk more and use green areas for joint activities do not have nerve disease, and they perceive green areas as essential for social health. Results also indicate that those visitors who use green areas for jogging do not take tranquilizers and spend more time outdoors. This study proves that positive relationship exists between green areas and human health, which emphasise the importance an benefits that green areas have in urban setting.

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Green infrastructure in peri-urban areas: The importance of urban dwellers' sense of place for recreational use of peri-urban areas

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A sense of place (SOP) concept has been recurrently used in landscape research to understand how people bond with their environment. On the other hand, the empirical use of sense of place approach is far from substantial. This research used the SOP concept to empirically compare, in two case study cities, how people connect with the peri-urban green space which they visited most often, for their leisure and recreational activities.

The study was based on survey data from inner-city dwellers in Ljubljana and Edinburgh, which are both cities of similar size but with different green space structure and distribution. Whilst Edinburgh is known for its well preserved green belt and several green corridors in form of canal and river paths, connecting the city centre with its outskirts, Ljubljana's main GI elements are wide green wedges in form of green hills and open meadows.

The findings revealed that people do not necessarily value the most the places they go to most often. Whilst in Ljubljana, the respondents, to a great degree, identified themselves with the peri-urban green space they visited most often, they were not dependent on it very much; they would not miss it when they were away and it did not provide enough satisfaction in terms of the things they liked to do most. In Edinburgh, place identity and place dependence were, as the analysis revealed, merged in to a holistic sense of place feeling. Understanding people's views on peri-urban green spaces is crucial for future GI strategies which can, in turn, enable enjoyable use of peri-urban green spaces for all residents.

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#DokterBos #DoctorWood - a Social Media campaign to raise awareness on the impact of nature, forest and green on public health and well-being (Flanders, Belgium)

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#DokterBos (#DoctorWood) is a social media campaign by the Flemish (Belgian) environmental ngo BOS+. Trough postings on Twitter, Facebook and our website www.bosplus.be we raise public awareness on the positive impact of (urban) green, forest and nature in people's health and well-being. We bring news stories, facts and summaries of research output in a temptative way for the general public. Through the campaign we also bring the theme (higher) on the political agenda, and on the agenda of other sectors and actors (including the medical sector).
In the presentation we will bring the story of the campaign, and we will show the #DoctorWood infographic.
www.bosplus.be/dokter-bos
https://storify.com/BOS_plus/dokterbos-bos
https://www.youtube.com/watch?v=cuOgQIziQRw
https://www.youtube.com/watch?v=BBSRBxRCVBU
https://twitter.com/hashtag/dokterbos?f=tweets&vertical=default&src=hash
https://www.facebook.com/hashtag/dokterbos?source=feed_text&story_id=1293194140720909

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Movement patterns through urban green space – implications for planning, design and management of NBS

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The neighbourhood green space is an important asset for the urban population, providing valuable ecosystem services supporting human health. Movement and why it is interesting. While the evidence base for that green space could contribute to some aspects of health and well-being, there is still a limit understanding of what aspects of the green space that are important contributors. Our preference for urban green space could provide one explanation, with an underlying hypothesis is that we prefer places that makes us feel good compared to those that do not. Understanding how people chose to move through these areas could hence potentially provide useful knowledge for increasing this understanding. Previous studies has shown that there are gender differences in the perception, sound experience, recreational activities as well as estimated well-being experience from urban green space.

In this presentation we will present result from a study exploring people´s movement within their local green space as recorded in a survey where they among other were asked to mark out their most common movement within the area on a map. The survey was sent out to residents living in close proximity to six different green spaces in the city of Gothenburg, Sweden. In this presentation we will present the result from three of these parks. The data showed that movement took plae over a large part of the green spaces. The data further showed that the movement pattern differed statistically significant between men and women.. The result will be discussed in relation to vegetation characteristics of the different part of the green space, and what the implications are for planning, designing and managing NBS that supports human well-being.

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Combined effects of air pollution and allergens in the city of Rome

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Urban green is an important aspect in the quality of life of citizens of modern cities. Nevertheless some ornamental plants cause allergic diseases in sensitive subjects that may be worsened by air pollution.

Studies on air quality are usually addressed to the evaluation of single substances and their specific effects: little is known about the cumulative effect that different pollutants may have on human health. Even less is known about possible combined action of traditional air pollutants with pollen and spores that have huge effects, in terms of allergies and asthma, on citizenship of the urban areas.

In this work the synergistic effect of PM10, PM2.5, NO2, O3 and airborne pollens (belonging to 5 families: Betulaceae, Cupressaceae / Taxaceae, Graminaceae oleaceae and Urticaceae) and fungal spore alternaria was studied in the city of Rome during five years (from 2011 to 2015).

For air pollutants, concentration values recorded by air-quality monitoring network of Rome were used. Pollens and spores data were detected by the Aerobiological Monitoring Centre of the University of Rome Tor Vergata. Effects on human health were evaluated on a group of 100 patients (aged between 4 and 17) by the free Allergymonitor™ application that records daily symptoms of hay fever, bronchial asthma and the prescribed therapies.

Data collected in the medical record were processed by 4 different Symptom Medication daily Scores and compared with time series of air concentration of mentioned pollutants, pollen and spores.

Statistical analysis allowed to highlight when concomitant high levels of allergenic species and air pollution occur, the influence of meteorological parameters, of the flowering calendar, of taking drugs and how these aspects affect symptoms in patients.

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SESSION 5
Health focused GI – Enabling healthy and active lives

POSTER

Detailed simulation of the effects of urban vegetation on radiant temperature – implications to health and well-being

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Mean radiant temperature (Tmrt) is a robust indicator of human thermal comfort, especially due to its ability to capture intra-city spatial gradients, enabling it to account for the effects of urban planning, design and adaptation measures. However, Tmrt studies are usually limited to small areas. In this work, Tmr maps are produced using a downscaling modelling technique that encompasses an average size town in Sweden.

Firstly, surface-atmosphere fluxes are calculated over the urban area by the Numerical Weather Prediction system HARMONIE, using the Town Energy Balance (TEB) model for downscaling to 1x1 km2 spatial resolution. The outputs are then used as atmospheric boundary conditions to the obstacle-resolving urban radiation model Solweig. A higher-resolution digital surface model was built based on laser scanning data from the Swedish land survey agency, describing land, buildings and vegetation at 2x2 m2 resolution. Results are plotted over outdoor pedestrian areas considering the actual land-cover (baseline conditions) and a planning scenario that eliminates all types of vegetation in the city. The simulation includes selected historical summer periods.

The analysis is focused on quantifying and explaining the intra-city spatial gradients of Tmrt, and its relation with the characteristics of grey/green infrastructure (e.g., dimensions, orientation and compactness). The overall benefit of urban vegetation on human comfort is extracted from the comparison between baseline and scenario. The Tmrt maps produced allow to identify outdoor spaces that can be critical during a heat wave, and to assess the paths and the proximity to cooler areas. This methodology can potentially help planners and health experts to improve the resilience of urban dwellers to thermal stress.

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Green Spaces and Brain Development: a Neuroimaging study

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Introduction: Contact with green space is thought to play a crucial and irreplaceable role in brain development; however, the available evidence on the impact of such an exposure on brain structure is non-existent. We aimed to evaluate the impact of lifelong exposure to green space on brain morphometric measures in primary schoolchildren and explore whether such an impact can mediate the association between this exposure and cognitive development.

Methods: This longitudinal study was based on a cohort of 253 primary schoolchildren (age 8-12 years) in Barcelona, Spain (2012-2013). Lifelong exposure to green space was assessed as the average of satellite-based normalized difference vegetation index (NDVI) surrounding all residential addresses of each participant from birth till the time of the study. High-resolution 3D anatomical images were obtained using an axial T1-weighted three-dimensional fast spoiled gradient inversion recovery-prepared sequence to measure voxelwise brain volume and tissue composition. Attentional function was assessed using hit reaction time-standard error in Attention Network Task (ANT) and superior working memory was assessed using d' in 3-back test.

Results: Lifelong exposure to green space was associated with increased grey matter volume in prefrontal and premotor cortices and white matter volume in prefrontal, premotor, and cerebellar regions. These structural changes were in turn associated with improved working memory and reduced inattentiveness.

Conclusions: Contact with green spaces was associated with changes in brain anatomy which in turn were associated with improved superior working memory and attentional functions.

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Green Learning Environments – Identifying best practice for non formal learning in the natural environment for children with special educational needs

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The Green Learning Environments project collected and reviewed practices for non-formal learning in green environments for children with mental disabilities and learning disorders in Belgium, UK and Slovenia. The poster will present the aims and the main result of the project: a. the inventory of existing practices and b. the toolbox will be developed and tested with methodologies, tools, and practices for tapping into the stimulants provided by nature for non-formal learning.

Why Green Learning Environments? To develop sensorimotor skills, training the senses, as well as calming and relaxing, nature is a great learning and therapeutic environment, particularly for certain groups of children with special needs. But such non-formal learning activities are not practiced regularly. During this project, we will enable children with special needs to develop contact with nature in a relaxed and safe way, and, simultaneously, enable more successful development of the basic skills they need in life. Moving children from schools classrooms to natural environments is also a great step toward the inclusion and integration of children with special needs into society.

The participants to the conference will be invited to contribute to developing the toolbox when visiting our interactive poster stand.

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Greenness and mortality and life expectancy in Spain: A small-area study

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A beneficial association between residential surrounding greenness and mortality has been suggested, but evidence for an association with life expectancy is very scarce. Air pollution may be a mediator in this association. We investigated the association of greenness with mortality and life expectancy in Spain, and the potential mediating role of air pollution in this association.

Mortality data from 2148 small areas covering Spain for years 2009-2013 were obtained. Greenness in each small area was assessed by the normalized difference vegetation index (NDVI). Annual levels of PM10, PM2.5, NO2 and O3 were derived from an air quality forecasting system at 4x4 km resolution. Greenness was linked to standardized mortality rates using Poisson regression and to life expectancy using linear regression. The models were adjusted for socioeconomic status (SES) and lung cancer mortality rates as a proxy for smoking, and accounted for spatial autocorrelation.

An increase of an interquartile range of NDVI was associated with an increased mortality risk of 8% (95% credibility interval CI: 5, 11%), but not with life expectancy. However, in areas with lower SES, the same increase in greenness was associated with a reduced mortality risk of 3% (95% CI: 2, 4%) and an increase of 0.3 years (95% CI: 0.2, 0.4) in life expectancy. We found interactions between greenness and the air pollutants. Within urban areas, the air pollutants showed stronger effects on mortality in areas with high levels of greenness (comparing the 95th percentile to the 5th).

Concluding, conflicting results were found. This might be due to limitations of the study such as unmeasured confounders, exposure assessment only by NDVI, and a complex association with SES. However, greenness could pose major health benefits.

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Allergic respiratory symptoms improvement after school green maintenance intervention: a pilot study in 2 primary schools in Palermo, Italy

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Background: Surrounding greenness may play a complex role on allergic health outcomes. Exposure to pollen-releasing plants may exacerbate allergic symptoms in sensitized children.

Objective: To evaluate the effect of the maintenance of greenness surrounding school on allergic and respiratory symptoms.

Methods: 244 schoolchildren, n=152 (62%) females, age 9-10 years, from two primary schools in Palermo were studied in 2013. A standardized questionnaire (ISAAC) for tracking allergic respiratory symptoms was administered to parents at T0 (March) and at T1 (May). Between the two times, a vegetation maintenance intervention (VMI) was performed. At T0, questions referred to the previous three months, while at T1 they referred to the previous two weeks. 11 symptom items ("did you have the symptom?") were codified as follows: 4 = "yes, every day", 3 = "yes, often", 2 = "yes, sometimes", 1 = "no, never". For each symptom, time comparison was performed through Chi-squared test for the presence (score 2-4) or absence (score 1) of the symptom. To account for the correlation between repeated measurements on the same subjects, the Generalized Estimating Equation (GEE) method was used to compare the mean score over all the 11 symptoms at T0 and T1.

Results: Significant reductions (T0 vs T1) were observed in the proportions of children with running nose (0.55 vs 0.29, $p<0.001$), blocked nose (0.54 vs 0.32, $p<0.001$), sore throat (0.62 vs 0.4), dry cough (0.34 vs 0.15, $p=0.001$) and feeling of upcoming cold (0.12 vs 0.06, $p=0.003$). The mean score over all the 11 symptoms significantly reduced between T0 and T1 (1.53 vs 1.36, $p=0.05$).

Conclusions: This pilot study offers an environmental prevention perspective for improving respiratory health in children.

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Longitudinal association of exposure to urban neighborhood greenness with body mass index in Kaunas preschool-age children

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Backgraund. Changes in the urban environment may have impact on overweight in childhood. However, an association between different types of greenness and children's weight is scarce. We aimed to examine the effect of longitudinal exposure to the objectively measured greenness level and risk for preschoolers' overweight.

Methods. This nested case-control study included 1489 mother-child pairs' residents of Lithuania. We identified children physical health by parents' responses to the standardized questionnaires. The international BMI cut-off points were used to determine of children's overweight/obesity. The environmental exposure was assessed by Geographic Information Systems. A multivariate logistic regression model was used to investigate associations between greenness exposure levels and children overweight controlling for potential confounders.

Results. The prevalence of overweight/obesity was 7.5 %. We find an association between lower greenness cover in different buffer zones and overweight/obesity in preschool-age children, however the results were statistically significant only within 100 m area. In a stratified analysis, using the high neighbourhood greenness exposure (NDVI-100>median) and the distance to city parks (<300 m) as a reference group, we found statistically significant increased risks for overweight/obesity for children with low neighbourhood greenness and farther distance from a park (OR 2.11, 95% CI 1.04–4.2∑5) after adjustment for relevant covariates.

Conclusions. Both higher greenness cover level and children's residing close to the urban park have beneficial effects on children's physical development. The park proximity effect on physical development is higher for the residents living in the environment with low greenness cover level.

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SESSION 6
Engaging communities and partners to participate in the co-production of GI

ORAL

Keynote Speaker
Green Infrastructure - essential for well-being in Cities of tomorrows - what does it need to implement it?

*Anna Steidle**
Chair WUP Europe

The presentation is a follow-up to my presentation in April 2016 in Torino with the title: "Why good Policy and Administration for Green Infrastructure needs the collaboration of Green Professionals" The message was: To get Green Infrastructure in a city, users and citizens, scientists and administration have to work together.

This presentation has the focus on the question "What kind of knowledge do all partners have to share in order to get Green Infrastructure in a City?". It sum up also the experience of 30 years of consulting for park departments and citizen workshop.

Starting with a link to the last presentation the system of having a green infrastructure and necessary partners will be shown. Important rules of marketing will be presented focused on GI:

"Why are the emotion of citizens are so important to get Green Infrastructure"?

"Why should the message be very simple?"

"Why are emotions so important?

"Why do we need citizens support?"

"Why is talking **with** them so important?"

"What is the role of the young generation and the children?"

"How to use the knowledge scientists provide?"

Presentation will finish with an answer to the question: "Why should we play cards in order to get GI?"

The presentation is a summary of knowledge everybody dealing with GI should have. It will be presented together with examples from the practice.

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Diversity in access to and benefits from urban green infrastructure

**O'Brien, L., De Vreese, R., Atmi_, E., Olafsson, A., Sievänen, T., Brennan, M., Sanchez, M., Panagopoulos, T., de Vries, S., Kern, M., Gentin, S., Saraiva, G., Almeida, A.*

The socio-cultural services and benefits provided by urban forests and green infrastructure are wide ranging and very important for urban populations in terms ofcontributing to their quality of life and quality of place. This presentation will exploreissues of social and environmental justice with a specific focus on who is notaccessing and gaining benefits from green infrastructure. Particular sections of societysuch as the income deprived, the disabled and ethnic minority groups may not have the same access to green infrastructure that more affluent sections of society enjoy,and they may also face exposure to more environmental risks. We will explore issuesof social and demographic distribution of access to and use of green infrastructure.

We draw on evidence from survey data of recreation use of green spaces and forestsfrom thirteen countries to highlight that some social groups are under-represented inhaving access to and gaining benefit from green infrastructure. We identify some ofthe barriers that different groups face in accessing green infrastructure. We concludethat while green infrastructure can provide a wide range of benefits not all section ofsociety are equally able to access this and gain benefits. This can be a social andenvironmental justice issue due to distribution of green infrastructure, with less andpoorer quality green infrastructure in more deprived areas – distributive justice. Thereare also potential procedural justice issues with some sections of society being lesslikely to be included in decision making about the development, creation andimprovement of green infrastructure. A range of policies, programmes and grassrootsactions are outlined from different European countries which target, reach out andenable and encourage a greater diversity of people –including under-representedgroups –to access and enjoy the benefits of urban green spaces.

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Productive Parks and the co-production of Green Infrastructure

*Axel Timpe**
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The European Commission's (EC) definition of Green Infrastructure (GI) as „strategically planned network of natural and semi-natural areas […] designed and managed to deliver a wide range of ecosystem services" (European Commission 6.5.2013, p. 3) includes multifunctional agriculture and other spaces of biologic production. Even before the EC initiative on GI a large variety of Productive Parks has been created especially in Europe. Often initiated in a bottom-up approach these parks contribute to GI networks of many city regions. As a form of Urban Agriculture they provide manifold Ecosystem Services to the GI (Timpe et al. 2015, p. 127). Productive Parks are a planning and design tool to create GI in cooperation with one of the most important land-users: agriculture.

Based on 16 case studies from 4 European countries the contribution will present a typology of Productive Parks and their importance for GI. The parks will be presented as a common good, co-produced by farmers, public authorities and civil society. Based on the case studies four levels of co-production have been developed. To the basic level joint production, the higher levels co-design, co-production and finally community co-production are added. On every level stakeholders can take different roles as producers, prosumer and produsers. The experience with Productive Parks shows that co-production can be a model for the governance of GI in general.

European Commission (06.05.2013): Green Infrastructure (GI) - Enhancing Europe's Natural Capital. Aktenzeichen: COM(2013) 249 final

Timpe, Axel; Cieszewska, Agata; Supuka, Jan; Toth, Attila (2015): Urban Agriculture goes Green Infrastructure. In: Frank Lohrberg, Lilli Licka, Lionella Scazzosi und Axel Timpe (Ed.): Urban Agriculture Europe: Jovis, S. 126–137

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Grassroots citizen participation in green infrastructure in NW and Central Europe: the case of Aachen City Region

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Approaches to the delivery, maintenance and management of Green Infrastructure (GI) in NW and Central Europe have generally followed a top-down, planning based format in contrast to more enabling based models evident in the UK. However, little attention has been paid to the role and potential of "bottom up" citizen led initiatives as a mechanism for creating, managing and promoting GI at a local level; the extent, contribution and viability of grassroots initiatives having largely been ignored by the research community and statutory agencies. The presence of local citizen led initiatives is evaluated within the Aachen City Region of Germany to determine the extent, viability and function of these activities in relation to the delivery of strategic GI objectives. The existence of partnership working along with the role and response of support structures from official agencies and enabling bodies is considered, as is the potential contribution that local initiatives can make to the delivery of strategic GI objectives. Comparisons are drawn between the relative effectiveness of grassroots initiatives between rural, peri-urban and urban communities. The common success factors behind these and the potential for knowledge transfer between rural, urban and peri-urban initiatives are discussed. Finally the question of how official agencies and supporting bodies might become more effective as enablers is considered in order to capitalise upon the potential contribution of citizen led initiatives to Strategic GI delivery.

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Implementation of Green Curtain Projects to Spread Sustainable Development in Education Systems and Local Communities

*Ikko Tucker**
Zayed University

The UAE is one of the leading countries, from the aspect of the commitment of governmental initiatives, to advance the achievement of a sustainable society. Prior to the Paris Agreement, the UAE Vision 2021 states that the Nation aims: "to ensure sustainable development while preserving the environment, and to achieve a perfect balance between economic and social development." Among the general population (both Nationals and expatriates), however, sustainable lifestyles seem to be the exception rather than the norm. As an educator in, and a resident of, the UAE, I always search for impactive ways to promote environmental awareness, habits, and values in education systems, as well as through local communities. Since the mid 2000s, a grass-roots movement known as the "green curtain project" has been exponentially spreading in the eco-conscious nation of Japan.

A green curtain is a biological shutter, made of vertically grown green plants to cover windows/walls – thereby, blocking the sun's radiation and heat during summer. Considering the implementation of green curtain projects as a possible means of education for sustainable development, I have been conducting mini-pilot studies at Zayed University (in the UAE). The green curtains are found to be an effective way to reduce surrounding micro-environment temperature and retain higher humidity during mid-day. More importantly, the natural curtains could foster a sustainability mind-set, and an intrinsic appreciation and value for nature. Thus, the "green curtain" is a fun and practical way to spread sustainability awareness among children, young adults, and general populations of a country with the largest per capita global carbon footprint.

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Digital breadcrumbs reveal spatial patterns and motives of recreational behaviour in urban forests in Helsinki, Finland

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Urban forests are multiple-use green areas offering important social, health and psychological benefits for our increasingly urbanized societies. However, they are intensively used and experience heavy pressure from a variety of everyday activities such as dog-walking, jogging, cycling, commuting or seeking restorative experiences. Recreational impacts in forests can cause various direct and indirect effects on the ecosystem such as soil compaction and erosion, decrease in vegetation cover and tree regeneration, changes in species composition, and fragmentation. In order to manage and protect forest natural resources, it is important to understand not only the bio-physical, but also the human dimension behind recreational use and impacts. We discuss the methodological, theoretical and practical perspectives of combining smartphone GPS tracking, Geographic Information Systems (GIS) and questionnaires to provide accurate, thorough and holistic understanding of the human-movement-environment interaction in urban green areas. We present empirical results from a pilot case study in Helsinki's Central Park where we introduced an innovative participatory web-based tool for collecting useful and up-to-date data on visitor spatial behaviour and motives. Such co-produced knowledge is crucial to managers aiming to maintain vigorous and pleasant forest ecosystems, while also catering for recreational activities and needs. We conclude that Volunteered Geographic Information and participatory GIS methods offer great opportunities for gathering valuable citizen information for planning and management while engaging the public in urban forestry.

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Using art, discussion workshops and social media to enhance biodiversity of parks and gardens in Finland

Nina V. Nygren, Eveliina Asikainen, Jere Nieminen, Tero Piirainen, Jarmo Saarikivi, Julia Prusi*
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Different urban green areas, such as public parks and private gardens, are an untapped resource for urban biodiversity in Finland. In the face of biodiversity crisis, climate change and increasing urbanization, we need more biodiversity in cities and more interaction between humans and all things living.

We have found in our previous research that nature conservation is too detached both administratively and in practice from park planning and management in Finnish municipalities. Also the active enhancement of biodiversity – such as creating new habitats, not just preserving existing ones - is a new idea in Finland that needs to be rooted in routine practices in gardening and park management. Our third angle is that most of Finnish public parks and green areas are still managed top-down. More collaboration, participation and empowerment is needed to create more biodiverse and invigorating public spaces where citizens can feel ownership.

Our research cooperative Tutkimusosuuskunta Tapaus project "Rikasta luontoa" ("Enrichen nature") 2016-2017 aims at enhancing biodiversity in these areas. Our strategy is to reach the professionals in to be able to mainstream the ideas, and to reach interested citizens with social media and art.

With the 2016 project grant (from Maj and Tor Nessling Foundation) we 1) organized 5 biodiversity enhancement workshops mainly for professionals but also for citizens 2) set up an internet page rikastaluontoa.fi and social media pages (Facebook and Instagram) and launched a hashtag #rikastaluontoa also in Twitter and 3) printed beautiful posters and post cards, painted by Julia Prusi, to inform about a biodiverse garden.

In 2017 we got a new grant with which we plan to do three new kind of workshops, continue online and social media activity.

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Building hydrocitizenship: the participation of communities in green infrastructure planning through creative engagement with water in the landscape

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The 'Hydrocitizenship' project is using creative co-production methods to engage communities in rethinking the ways in which they live with each other, their environment and water in a range of neighbourhoods in four case study areas in the UK. 15 Researchers from 9 universities are collaborating over three years working with arts practitioners and community groups to refine and advance participatory research practices and outputs. The focus is on building new knowledge, the strengthening of community networks and the consideration of innovative Nature Based Solutions (NBS). This paper presents research from the Shipley case study, situated in the major Leeds-Bradford conurbation in Yorkshire,

UK where researchers are using arts-based methods (including performance and

story-telling) in conjunction with communicative and collaborative processes to investigate people's relationship with green-blue infrastructures and to foster ways to build more interconnected communities and environmental resilience.

Initial findings suggest that a range of methods is useful. Creative engagement with researchers acting as facilitators in difficult situations can achieve new networks between communities and policy-makers and can build community capital to provide the stimulus for people to address difficult issues brought about by severe flooding and a disconnect with local landscapes. Three key messages are revealed concerning the use of creative methods in environmental research; these can:

1. Help provide neutral ground where stakeholders and ordinary people can meet;
2. Engage with all ages and knowledge levels within communities
3: Allow communities to engage with serious and important issues through enjoyable activities

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French capital of biodiversity award

*Gilles Lecuir**
NATUREPARIF (Regional agency for nature and biodiversity in Paris Region)

The contest "French Capital of Biodiversity" aims at rewarding the "French Capital of Biodiversity" in other terms the most active municipalities regarding policies and actions in favor of biodiversity. The Contest 2016 edition paid particular attention to the central theme "Soil and biodiversity»: cities were invited to present exemplary actions in terms of land use or urban planning and planning documents; manage public green spaces in harmony with nature; ecological restoration of natural habitats ; fight against the soil sealing or actions relating to urban agriculture and forestry

Initiated within the framework of a EU LIFE + program, it has been organized since 2009 by Natureparif, regional agency for nature and biodiversity in Île-de-France, with many partners, and with the support of the Convention on Biological Diversity. It is open to cities and towns of more than 2000 hab. The award includes a survey of forty questions both in urban planning as the management or communication. The 3-4 best of each category of community (small cities, medium cities, large towns, intercommunal) are then the subject of a field visit by members of the Scientific and Technical Committee who draft an inspection report. Based on these reports, Committee members choose the winners in each category and among them a French Capital of Biodiversity community for the year.

The objective of the operation is to promote the integration of biodiversity in urban development policy and management of cities. This provides the opportunity for communities to value the actions taken for the conservation of nature, but also helps to raise awareness and inform the public on the issues biodiversity.

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"Not in their front yard" The opportunities and challenges of introducing urban meadows: a local authority stakeholder perspective

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Despite the growing evidence base for the value of nature-based solutions to the management of urban GI for people and wildlife, there is little research focusing on the associated challenges and opportunities of implementation, as perceived by land managers. Our study addresses this gap by exploring stakeholder manager perceptions of the opportunities and challenges of introducing perennial urban meadows to prioritise biodiversity and human aesthetic objectives. Meadows were successfully established in Bedford and Luton, UK, between 2013 and 2015 as a practical experiment co-produced in real-world urban spaces with Luton Parks Service and Bedford Borough Council. We interviewed eight stakeholder local authority managers involved to identify factors impacting on the feasibility of future meadow establishment in urban areas. Key factors identified include: aesthetics and public reaction, spatial context, human resources and economic sustainability, local politics, communication, biodiversity and habitat value and physical factors affecting establishment and maintenance. The emphasis placed on specific factors reflected managerial role within the local authority and personal values, which were related. Managers with ecological backgrounds demonstrated biocentric value orientations, yet were self-aware and empathetic towards varying public values. Managers were aware of a changing public values leading to increasing acceptance of a messier urban aesthetic. Our findings have wider relevance for the implementation of nature based- solutions. Changes in management practice such as the introduction of meadows have significant political, strategic, and economic implications and cannot be viewed purely as a technical challenge.

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Artificial Intelligence to manage green infrastructure

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Since 2002 **DECAsrl** put effort into research&development creating a web based platform: a revolutionary system called "**Welcome2**®" that is a new integrated system for gather, carry and storage massive data from sensors and organize human activity on the field. DECAsrl developed in Welcome2® a vertical project with MIUR Italian Minister of Economic Development, called **GHW** (GrapeHealthWine) that uses *Artificial Intelligence* to improve the healthy substances of wine and reduce damaging features, through tracking every single cultivation activity. This year this kit obtained the patent, applicable to any plantation and forest, saving the environment. This patented kit is a technological system totally Web Based, at all corporate levels and in interconnection with any other external realities, which - through innovative measurement and tricks along the various processes, based on sensors, software and assistive technologies - will be able to provide qualitative and quantitative data in a standardized according to the protocols developed. In particular, the predictions and forecasting of diseases, pollution, flooding etc. developing them over time, give alerts manage risk, through the use of *neural networks* and *fuzzy-logic models*, allowing companies to act in advance to ensure with effective and positive impact on health objectively demonstrable. This platform is a global system applicable to all sectors of agriculture-forest etc., so as to have a complete control of whatever plant is growing, and to be able to produce in a more efficient and less costly way, while respecting the environment. This integrated system can manage urban forests, climate and human interaction.

In summary, is a system of innovative technology, operating on standard certificate, consisting of an advanced platform and several smart technologies and integrated in support of City environmental management, allowing them to track, analyze and act in objects along the phases of the activity to monitor, maintain and improve levels of health aspects of Cities life world wide.

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The effect of ground surface permeability on the growth, canopy density and transpiration of urban trees in Gothenburg, Sweden

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One of the ecosystem services provided by urban trees is the cooling effect caused by their shading and transpiration. However, in order to provide these services, urban trees need to endure many stress factors such as the widespread use of impervious surfaces in the vicinity of trees. Knowledge of the effect of tree growing conditions on the growth, health and physiology of urban trees can prove useful in estimating the cooling efficiency of urban greenery as well as in urban planning and management. The aim of this study is therefore to investigate the direct effects of ground surface permeability on stem and current-year shoot growth, leaf area density and transpiration of street trees in Gothenburg, Sweden.

Measurements were conducted on mature street trees of seven species common in Gothenburg: Tilia europaea (Common lime), Quercus robur (English oak), Betula pendula (Silver birch), Acer platanoides (Norway maple), Aesculus hippocastanum (Horse chestnut), Fagus sylvatica (European beech) and Prunus serrulata (Japanese cherry). Trees with a larger fraction of permeable ground surface in the vertically projected crown area were found to have an enhanced stem and current-year shoot growth, leaf area density and transpiration. These results indicate that the growth, vitality and cooling effect of street trees may be compromised when the permeable surface area in the vicinity of the tree is small.

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The Green Agenda; a public private partnership approach to the realisation of ecosystem services (ESS) by urban green infrastructure

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In the Netherlands in 2015 a public private partnership named "de Groene Agenda" (the Green Agenda) was initiated that aimes at bringing together expertise from urban green managers and companies with scientific knowledge in order to stimulate the actual use of the potential benefits of urban green infrastructure. This initiative is one of the projects within the so-called Top-Sector Horticulture & Starting Materials in which the Dutch Ministry of Economic Affairs co-finances joint initiatives from companies and research institutes. The

4-year project Groene Agenda has been initiated by Royal FloraHolland (cooperative Flower Auction), iVerde (joint platform of Dutch horticultural organisations) and Wageningen University and Research.

Urban green is more than just nice to see, it positively influences human health and well-being. As such it can contribute to the solution of many of the problems of modern cities. The project wants to provide planners, managers and practitioners with clear

information and arguments that underpin the benefits of green. Moreover it also wants to support the horticultural and urban green industry by providing sound information needed for development of new concepts aiming at the production of specific benefits of urban green infrastructure. To achieve this the existing scientific information on the effects of urban green on health and well-being is summarized in set of FactSheets on the effects of green in and around houses, schools, hospitals and offices. Additionally, a set of research projects has been started that address specific benefits. One of the projects focusses on EcoSystem Services of urban trees. The paper will summarize the Green Agenda programme and present the results of the latter project on ESS of urban trees.

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Introducing the concept of American Urban Field Stations into European cities

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My aim is to analyze how the concept of an Urban Field Station (UFS) works in the United States and apply that model to Europe. I carried out my research mainly in New York City. I also visited Baltimore and Philadelphia, which show different urban conditions (socio-cultural, economic and urban planning). UFS is a physical place to conduct research, based in New York City, Baltimore, Philadelphia, Chicago and San Juan (Puerto Rico), and a network of relationships among scientists, practitioners, and facilities working on urban research programs, using a social-ecological approach.

The main part of such research consists of the assessment of the UFS model, which was incubated by the U.S. Forest Service, involving public agencies operating at the citywide, regional, state, and national scales collaborating with civil society groups in order to create innovative research programs on social-ecological systems and natural resources management. In particular, thanks to the analysis of the UFS model, my work aims to bridge the knowledge gap between urbanization and its quantitative and qualitative impacts on the well-being of the population and highlight the challenges and the opportunities for urban areas and the best practices in planning and managing urban green infrastructures. The project also aims to contribute to the conceptual and scientific methodologies of current urban green studies, by involving European and global case studies. Finally, my research focus on the integration of the UFS core aspects in a potential European Urban Field Station model, based on the structure of European cities, highlighting the potential sources of funding and the assorted policies that are relevant to launch the UFS concept in Europe.

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Determinants of indoor gardening and choice of public green spaces among Khartoum state's dwellers Case Study of Khartoum State – Sudan

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It has been proved that greenery inclusion in cities inform of private and public green spaces, city forests, green belts has a positive health returns on cities' inhabitants. Trees and green lawns help sequestrating Carbon Dioxide (CO_2) and generating Oxygen. They help dissipating urban heat islands and its roots and umbrella help stabilizing the soil, thus they reduce occurrence of dust storms mainly in tropical arid climate. Khartoum, the capital of Sudan is densely populated metropolitan with hot, dry and dusty climate. As per climatic projections of 2050; Khartoum is expected to face the worst in term of increasing temperature and decreasing precipitation. Provision of public and private blue-green spaces can be a traditional measure to comfort in such climate and it can help increasing adaptive capacity of the individual household to the expected climate change impacts; specially, increase of the temperature.

This paper investigates dwellers' choice determinants for specific public green spaces over other, user's satisfaction towards the esthetic and amenities provided by the exiting green spaces and what age group often uses public green spaces? This study uses case study methodology following both quantitative and qualitative approaches. 400 questionnaires have been distributed and analyzed to attain the results of this study and a wide array of governmental documents has been reviewed.

Results from the fieldwork yielded that Khartoum state's inhabitants have limited accessibility to public green spaces due to inadequate number of green-blue public spaces compared to the number of inhabitant. On the other hand, indoor gardening is also facing group of hinders such as; water shortages, house ownership and fears from providing breeding environment for diseases' vectors like Mosquitos. 56.3% of the sample hasn't planted trees inside or outside their homes. However, 67% of them showed tendency towards growing trees in or outdoors. Free entry and adjacency of the green space to residential neighborhood are among the main factors that encourage inhabitants to choose specific green space over other, while young singles and young parents are considered to be the major users of the green facilities in Khartoum. Nile cornice is the most attractive spot for recreation due to ease of access and free entry. The study has concluded that Khartoum lacks qualitatively and quantitatively public green spaces. The study has recommended municipal incentives should be offered to Khartoum state dwellers to increase communal gardening and indoor tree plantation. It has been proved that greenery inclusion in cities inform of private and public green spaces, city forests has a positive health returns on cities' inhabitants. Khartoum, the capital of Sudan is densely populated metropolitan with hot, dry and dusty climate. As per climatic projections of 2050; Khartoum is expected to face the worst in term of increasing temperature and decreasing precipitation. Provision of public and private can help increasing adaptive capacity of the individual household to the expected climate change impacts; specially, increase of the temperature.

This paper investigates dwellers' choice determinants for specific public green spaces over other, user's satisfaction towards the aesthetic and amenities provided by the exiting green spaces, what age group often uses public green spaces? plus inhabitants' tendencies towards indoor gardening. This study used case study methodology followed both quantitative and qualitative approaches.

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qualitatively and quantitatively public green spaces. The study has recommended municipal incentives should be offered to Khartoum state dwellers to increase communal gardening and indoor tree plantation

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SESSION 6
Engaging communities and partners to participate in the co-production of GI

POSTER

Participatory planning process of an urban green space involving school children

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Rethinking urban spaces and green areas according to the needs of citizens is pivotal to make the cities more liveable. A participatory planning project, called “Il verde che vorrei/The green we want" was developed during the school year 2013-2014 in Monsano municipality (Italy; population: 3405) involving citizens, students and teachers to design the urban green space and school garden (about 18.500 m2) located next to the local elementary and young high school. Recreational activities were organized to collect children suggestions and requests related to the green spaces and participatory approach was used also with teachers and citizens in order to involve as key player from the very beginning of the planning process the main beneficiaries and stakeholders of the park and to promote their sense of belonging to local community and their sense of public responsibility in the use of urban green spaces. The approach was also oriented to discourage vandalism against the green space and enhance the recreational purpose and encourage the attendance of children and families at the garden.

An educational programme was proposed to the classes of the school, involving a guided visit of the area to explore a new space and a creative workshop in the classroom to build with different materials a scale model of the desired green space inducing children to practice their manual skills and stimulate creativity. Suggestions and children desires were collected in class schematic reports. Participatory meetings were organized for citizens. Outcomes of children and citizens were adopted by designers and transformed into a final plan of the area.

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Urban biodiversity as a planning tool in informal settlements

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We live in an increasingly urban world because the accelerated population growth and urban expansion. This trend demands resources that generate unprecedented pressure on natural ecosystems and presents an urgent challenge on conservation of biodiversity, natural habitats and all the ecosystem services that society depends on. In spite of this, the relevance of biodiversity and its benefits do not represent an immediate concern to more than a 900 million people living in slums whose main concern is where their daily food will come from as well as without basic services and with unhealthy living conditions.

For that reason, the cities play a critical key role in conservation and use of biodiversity, where they define the existence of ecosystems. Therefore this research tries to integrate the urban biodiversity to territorial planning in slums through a comparative analysis of cities (Rio de Janeiro, Cape Town and Medellín), the study of planning tools and criteria and the proposal of "local actions for urban biodiversity" through their own dwellers that are the builders of their territory that can recognize the advantage of promote biodiversity in their livelihood like health, food safety, green infrastructure, resilience, citizen participation. These actions are based on sustainable development of these communities looking to improve both the quality of life of residents, the neighborhood and the surrounding ecosystems city, and composed also by a toolkit that presents, to any inhabitant of an informal settlement, a wide range of opportunities and successful examples of integrating the challenges of poverty and degradation of our ecosystems

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Finding a common language: preliminary results of a world stakeholder survey in the field of urban forestry and green infrastructure

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The planning and management of urban green infrastructure requires the involvement of a complex network of stakeholder groups. These different actors all make essential contributions to the implementation of scientific research in actual practice. Therefore an effective communication between scientific researches and practicioners - both stakeholders of Green Infrastructure - is essential. We present here the initial results of a survey that examines the ways in which knowledge is transferred from scientists to the stakeholders and the different modes by which these actors collaborate.

Based on a sample from 18 countries, the survey's preliminary results indicate that respondents place a high importance on the accessibility of online information linked to tangible problems and traditional approaches (workshops, conferences) for filling scientific and technical gaps, while e-learning is not yet widely used.

Representing four groups of stakeholders (scientific researchers, private practitioners, policy makers and community activists), most respondents hold positive attitudes towards collaboration and most have collaborated with members of at least one other group. The limitations and constraints are mainly related to bureaucracy and the lack of common vision. Though most respondents understand the importance of forming cohesive teams and finding a common language to bridge diverse disciplinary backgrounds, in practice this behavior can often not be seen.

New collaborations are generally facilitated by direct contacts and connected to interpersonal trust, and professional associations are considered to be effective for facilitating the exchange of ideas and reinforcing individuals' identity and credibility. Training activity is considered crucial, and a high level of satisfaction was expressed not only with the knowledge acquisition and job benefits, but also with their function as a connecting element between participants, activating new collaborations between trainees.

Future models of knowledge transfer will have to consider the long-term potential of e-technologies as learning delivery services. However, practical problems like using e-learning in an office, have to be solved. Training must not only deliver a certification but must be based on high-quality content, include practical activities, and it must enhance the possibility for personal contacts.

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Productive use of vacant city-owned land

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The New York City Deparment of Transportation (NYC DOT) installed a temporary community garden, the "New Roots Community Farm", for refugees and South Bronx community members on vacant DOT land after a bridge construction project was postponed.

The community garden is a partnership with GreenThumb, a community garden program at NYC's Department of Parks and Recreation and managed by the International Rescue Committee (IRC). The garden features about 60 plots and planting beds, an aquaponic greenhouse, a composting area, storage, bee hives and a rainwater harvesting station. The community garden allows for refugees, often with agricultural backgrounds and local community members to grow fruits and vegetables, helps refugees connect to their new community, and also demonstrates opportunities for putting under-utilized spaces to good use, allowing for the absorbption of stormwater.

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SESSION 7
New governance and funding models for GI

ORAL

Keynote Speaker
Managing an urban forest of opinions – new governance models for green infrastructure

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Where urban forestry has often been dominated by governmental decision-making, recent years have seen the emergence and recognition of more complex, multi-actor processes. The governance of urban forests and other green spaces takes many forms, operates at different scales and involves a wide range of governmental, business and civic society actors. Based on research in Asia, Europe and North America, an overview and analysis is presented of current urban forest governance across the world. The state-of-art of green infrastructure governance research is assessed, revealing an increasing body of knowledge and governance case studies from different contexts. City governments and urban foresters have to manage a true 'forest of opinions', with increasing and diversifying urban populations and major challenges such as climate change creating further challenges. The role of different governance models is discussed in relation to selected case studies, with emphasis on the changing roles of governments and other actors. Moreover, the changing role of municipal urban foresters needs to be considered. Different governance arrangements and models are presented. The issue of linking up different scales of urban forest governance, ranging from the neighbourhood to the metropolitan level is highlighted. Finally, an agenda is suggested for future research on governance of urban forests and other green infrastructure.

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The impact of economic growth oriented development policies on green infrastructure efforts in Turkey

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As shaped by the neoliberal policies, the new market order implemented at the global level in 1980s has transformed especially the urban land use toward rent-seeking. Developed countries have responded to the unfavorable transformation caused by those policies on urban land use by preventing rent-seeking behaviors and developing common strategies, such as Green Infrastructure, Habitat 2000, and Natural Solution, to ensure the consideration of resources from a sustainability point of view. Developing countries, however, let alone developing strategies for preserving the existing resources, have shown a tendency to consume their natural and cultural resources ever more rapidly.

The policies towards consumption of natural and cultural resources in Turkey have caused the natural and cultural landscape at the perimeter of urban areas to transform toward the demands of the capital owners, and the depletion of resources. Due to the growth-oriented governance sensibilities of the current government and the legal infrastructure it accordingly-reshaped, what is left of the green areas in the cities, as in the case of Taksim-Gezi Park, are intended to be destroyed for the purpose of building hotels, residential buildings, mosques, business centers, etc. In addition, the forests are prepared to be sacrificed for large infrastructure projects, such as, airports, highways, etc. and for touristic purposes, such as, hotels, golf courses, etc.

In this study, it was aimed to examine the magnitude of change on land use categories in Istanbul, as a large city in a developing country such as Turkey. This study was conducted in two phases in Istanbul, a city with a population of 15 million. In the first phase, the stress on natural resources was examined for the period of 2002-2016, the period of large projects (3rd airport, 3rd bridge over the Bosphorus, etc.) implemented by the governments of AK Party. In order to determine the magnitude of the stress, multi-time satellite images were categorized, change analysis was performed, changes in the landscape patterns were presented statistically, and predictions were made on the magnitude of the change in the future by utilizing scholastic modeling processes. In the second phase of the study, a conceptual model was constructed by evaluating applicable strategies for Turkey in the framework of Green Infrastructure.

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The FAO Guidelines on UPF: a first step towards a greener, healthier and happier cities

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Cities occupy only 2% of the planet, but their inhabitants use 75% of its natural resources. According to recent estimates, 70% of the global population will live in cities by 2050, with most of the growth occurring in less developed countries. The New Urban Agenda (HABITAT III) includes many principles and commitments that refer to green spaces in urban and peri-urban areas, recognising their role in future sustainable cities. If properly planned, designed and managed, forests and trees in urban and peri-urban environments can help make cities safer, more pleasant, healthier, wealthier as well as more diverse and attractive, making an important contribution towards the achievement of a more sustainable and resilient model of urban development. Urban Forests and Green Infrastructure are increasingly becoming a standard component of urban planning in developed countries, but this is not yet the case in many less developed countries, where income is highly diversified and social equity has glaring discrepancies. Boosting urban and peri-urban forestry implementation requires efforts to raise awareness of decision takers at all levels on the benefits of UPF and to transfer lessons and expertise to less developed countries, where the predicted increase in urban population is expected to have severe socio-economic and environmental impacts.

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Governance tools to enable implementation of nature-based solutions

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Nature-based solutions (NBS) and green infrastructure are fundamental to a sustainable future for urban areas. While the technical site of these solutions has been extensively studied, a key challenge is its large-scale implementation. Particular features of NBS inhibit such a move forward. Natural processes and dynamics are inherent characteristics contributing to overall biodiversity, but also introducing a new level of unpredictability. In addition NBS are tailor-made, which complicates ex-ante proof of concept. A third specific feature is multifunctionality: ecosystem services such as recreation, flood safety or water quality are combined with environmental enhancement. Combining functions in the design requires cross-sectoral cooperation of governments, stakeholders, private companies and NGO's. Dealing with unpredictability and multifunctionality requires novel governance approaches, well-adapted to the inherent characteristics of NBS. We present three helpful governance tools to enable NBS implementation. First is a game-theory based approach to identify the relevant strategic interactions between actors. This structured method shows how win-wins can be achieved and what is needed for actors to value NBS. The second is a knowledge-arrangement approach, which identifies how knowledge development affects the NBS decision-making process. Knowledge development is often as fragmented as decision-making, although unnoticed. The last is adaptive co-management, a tool to enhance learning and foster cooperation. The tools are illustrated with applications in the Netherlands coastal areas, known for severe flood risk, high environmental value, and intense stakeholder involvement. Our tools are helpful in identifying and dealing with local NBS challenges.

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Spontaneous natural redevelopment of urban voids in small cities: planning challenges from transient woodlands

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Biodiversity in urban areas is significantly connected to anthropogenic actions. For example, novel woodlands are growing on urban voids previously intensively used by humans. These voids with spontaneously developing vegetation generally are not the result of urban planning and zoning, but rather the consequences of temporary or permanent economic and social changes. Here we focus on the implications of transient woodland patches for nature conservation, ecosystem services provision and urban planning, showing the examples of Padova and Bibione, two northern Italian small cities. Alien tree species are an important component of these woodlands and can influence understory species composition. However, also typical species of native communities are forming these forest patches. These woodlands are heterogeneous and different urban features can play a role in shaping their biological communities. Therefore, these green infrastructures provide further variability to green urban spaces, even in small cities. Multiple ecosystem services may derive from these woodlands highlighting their important role to ensure sustainability in cities. Novel planning and management solutions are needed to adequately recognize and promote the benefits deriving from the dynamic maintenance of these transient forests.

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Strategic analysis of Urban Forests

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In Swiss cities many types of inventories exploring the nature of green infrastructure exist. However actually there are no Urban Forest Plans integrating all publicly and privately owned trees within the urban area in one strategy. On the forest sector side different management plans on different levels are implemented, but the interaction with the urban development and the quality of urban life is rarely thematised in these plans. As the population as well as the cities grow and the interconnections between the grey and the green world is increasing, the strategic importance of urban forests (UF) becomes crucial.

Based on a literature study and based on existing tools and guidelines (e.g Lindholst et al 2016, FAO 2016) a method was developed to analyse the strategic importance of UF within the future city development. The method was implemented as a pre-test in nine cases in different regions in Switzerland. The goal of this study was (a) to detect the management information needs for UF, (b) to test an analysis tool within a local context and then (c) explore possible standards for strategic management rules.

As a result an analysis tool combining 13 criteria and 60 indicators was developed and tested in nine urban areas with different types of forests. In each case an analysis report was provided showing hot spots and developing recommendations for the future integrated management of these forests. The six cases were then compared on a national level. Based on the results of this study conclusions were formulated for future UF management and governance.

Lindholst, A.C. et al., 2016: Urban green space qualities reframed toward a public value management paradigm: The case of the Nordic Green Space Award.

FAO 2016 : Guidelines on urban and peri-urban forestry. FAO

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Light shades of green: potential governance implications of the European Green Capital Award

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This paper analyses the environmental governance consequences of the European Green Capital Award (EGCA). The EGCA is a green city branding scheme steered by the European Commission and is a policy tool used to govern urban green infrastructure (UGI) conceptualization, delivery and management. The award, originally drafted by European mayors and local authorities, looks to encourage cities toward climate resilience by the horizontal sharing of environmental knowledge and applications at the city scale. The EGCA thus ranks, brands and celebrates select European cities for their environmental performance in establishing the indicators by which environmental success is determined, and by encouraging the 'horizontal' exchange of 'best practices' amongst cities. In this sense, the EU is assuming a major role in the development and delivery of UGI policy at the municipal level and the broader European urban sustainable development agenda. Yet, only limited critical attention has been paid to the EGCA and its role as a tool in generating notions of European urban sustainability, UGI and environmental governance. Understanding how this award could impact urban environmental policy and UGI is important because green city branding schemes such as the EGCA are an agenda setting tool, establishing and entrenching particular political and cultural norms (Kingdon, 1994; Govers and Go, 2003; McKendry and Janos, 2015). We therefore examine specifically what is being promoted in the award, through an analysis of i) EGCA indicators and ii) the framing by the winning cities of their strategies and 'green practices'. With this analysis, we aim to shed light on the explicit and implicit interpretations of urban greening as a result of the EGCA.

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SESSION 7
New governance and funding models for GI

POSTER

"From Canned goods to freshware" On the need for a new kind of input to improve GI-management

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Management ultimately aims at improved user satisfaction; solutions leaving inhabitants better off, with as little sacrifice as possible, not exposing the management system to untimely strains and exceeding expenditures. In GI, the measure of user satisfaction is often convoluted or indirect, consequences are often unclear and in most situations both observed effects and responses to them are significantly lagged.

Attempts have been made to design tools for better management – i.e. richer and more complex contact between management and users. Today management systems use tools like e-mail and web-based reporting systems. Still, the general experience is that such tools reach the public only to a low degree. Qualitative and richer reflections are sought through surveys, either field-based or postal/internet based. They may return a rich catch, but are generally low in return (response rate) and supply historical data due to time lags. Thus, presently there is no easily accessible, immediate and dialogue-empowering tools to be used.

A few have started to look for viable tools to overcome these challenges. When it comes to simpler and more static information, GPS-based smart-phone apps now exist, generally developed as an add-on for personal training apps. When jogging, the app tracks and stores information about where you were at various times. Problem is that presently this information is not accessible to GI/landscape management systems. Further – there are no tools to enable managers/scientists link localization data to directed, semi-syncronous dialogue with users.

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Porto Fifth Facade Project - A new GI policy for the city of Porto, Portugal

*Paulo Palha, Beatriz Castiglione**
ANCV - Portuguese Association for Green Roofs

Green infrastructures (GI) are becoming increasingly popular in Portugal, due to its many benefits, such as improving building energy efficiency, increasing biodiversity, reducing the heat island effect, waterstorm manegement and providing more green spaces in the city. Nevertheless, much remains to be done in order to include GI's as a strategy to fight climate change in Portugal.

Currently, no portuguese city has GI policies included in their legislation. However, in August 2016, the "ANCV - Portuguese Association for Green Roofs" signed a pioneer project entitled "Porto Fifth Facade" (PQAP) with the Porto city council (CM Porto). The main objective of this innovative consultancy project, which will last for 12 months, is to define which models the CMPorto should follow to include GI, in particular green roofs, into the urban planning, environmental and green spaces strategy of the city.

The study area is the municipality of Porto, which has around 42km2 and a population around 220.000 inhabitants. Porto is located in the northwest of Continental Portugal, limited by the Atlantic Ocean in the west and by the Douro River estuary in the south.

The methodology of PQAP will include the participation of research groups from different national institutions of high education as well as interaction with foreign cities, community associations and a deep literature review on the subject.

The aim of this paper is to present and discuss the results of different studies within the PQAP Project, such as the percentage of buildings in Porto that has the possibility to include green roofs and the most suitable areas for different types of policies. It is also expected to present the firs proposal of policy model defined by the working group of the project to be implemented.

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Trees and citizens: conflicts or mutual benefits?

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Cities occupy only 2% of the world's land surface and are home to more than 60% of the world population; it is expected that this percentage will rise to 80% in 2020. It is clear that the urban environment is different from the natural one and it results in a reduction of the average life of trees in cities. The spread of the Green city is considered one of the main indices of civilization and livability of urban areas. However, there is a hostile attitude between citizens and trees: for example, trees represent obstacle to the car park, roots damage sidewalks, leaves will dirty streets, not to mention, for those who suffer, allergies caused by pollen during blossom. The relations between plants and citizens have a role in the development of our society, affecting areas of environmental, social and economic science. In an urban environment, people communicate with Green through formal and informal rules, management strategies and cultivation practices; validity or not of these institutions has an impact on the health of trees and their ability to deliver these benefits in terms of health and quality of life of society. It is important to participate in the choices of the public administration, in order to quantify and communicate to the citizens the economic value of environmental assets and functions, defined ecosystem services; even if the estimation is uncertain because of the absence of market value. Tools of planning and management of the Public Administration (in Italy they are called "Piano del Verde" and "Regolamento del Verde") have not yet been adopted by all municipalities, therefore, even today, there is necessity to strongly confirm the importance of protecting the urban Green as a common good.

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SESSION 8
Science-policy implications of GI

ORAL

Keynote Speaker
Towards an improved science-policy-society interface for Green Infrastructure

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The loss of biodiversity, including the decline in nature in our cities, is not only a concern in itself, but has meant an increasing risk to the delivery of essential ecosystem services such as the moderation of extreme events, including flooding, and the provision of green space for recreation and mental and physical health. Indeed, there is an increasing awareness that many challenges, from climate resilience to urban regeneration, can be met with nature-based solutions. The necessary understanding of these challenges and the successful implementation of nature-based solutions does, however, require both an accessible, relevant knowledge base and a functional science-policy-society interface. The EKLIPSE project will build a mechanism for supporting better policies on nature-based solutions based on the best available knowledge and an enhanced dialogue between researchers, policy makers and other interests.

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Urban green infrastructure: aims and perspectives from the perspective of urban nature conservation in Germany

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Nature in urban areas has been considered in nature conservation legislation in Germany for 40 years. Issues of urban nature are also part of important federal policies: The National Strategy on Biological Diversity (2007) contains a vision, aims and measurements for urban landscapes. The Nature Conservation Campaign 2020 of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB, 2015) anchors „Experience of green in the city" as one of ten prior fields of activity for nature conservation. Finally, the initiative „Green in the city" of BMUB (2015) seizes biodiversity and the manifold services of urban ecosystems for sustainable urban development.

The Federal Agency for Nature Conservation (BfN) has dealt with issues of urban nature conservation for 10 years including both scientific and implementation projects. The presentation will focus on some of the Agency's recent projects such as on the theory and implementation of the concept of "double inner urban development" which aims at urban densification in concert with development and qualification of green structures. Currently, a common definition of urban green infrastructure is being developed in close interaction of scientists and municipal stakeholders (see contribution Pauleit et al.).

Definitely, cities and municipalities are important partners for safeguarding biodiversity as well as planning and management of urban green infrastructure. Therefore, in 2010 BfN initiated a dialogue process with German municipalities which resulted in the foundation of the "Alliance for Biodiversity". This alliance is a platform for the intermunicipal cooperation on all issues of biodiversity, urban nature and urban green infrastructure and can serve as a model for other countries.

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Supporting urban climate change adaptation using green infrastructure: the case of Czech Republic

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Future and ongoing climate change-related risks and need for adaptation represent major issue in science as well as practice at all spatial administrative levels. Adaptation strategy of the Czech Republic at national level was adopted by the government in fall 2015. In order to support mainstreaming of adaptation, our project aims to implement the strategy into the decision-making processes at local level (adaptation strategies of individual cities). We, therefore, aimed to initiate and further develop the process of preparation of urban adaptation strategies in several pilot cities (such as Prague, Brno, Pilsen), while promoting use of green infrastructure. The adaptation cycle was promoted as a generic framework to adaptation.

Firstly, we assessed climate-related risks and impacts experienced in cities in the present and expected future impacts. To ensure effective participation of stakeholders, we organized a series of participatory workshops, where climate change-related risks were evaluated.

Secondly, various adaptation measures have been prioritized by stakeholders using multiple criteria (including economic aspects, timeframe, etc.). Ecosystem-based approaches (use of green infrastructure) to adaptation were shown to have a very high priority among stakeholders during the workshops. Thirdly, main barriers as well as opportunities for implementation have been identified using findings of an institutional analysis.

The above mentioned outcomes from particular city were used to develop city´s adaptation strategy. The adaptation strategies of Prague, Brno and Pilsen will be presented in this paper also in the context of mainstreaming the adaptation efforts into the local decision making.

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Green Roofs as Smart Sustainable and Economic Solution

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Green roofs need few additional costs related to non vegetated roofs. In comparison to the complete investment, these green infrastructures offer a range of ecological benefits. As an example, with green roof technology, several demands of environmental mitigation regulation can be achieved, such as evaporation cooling, rain water retention, enhance biodiversity. Direct incentives or fixed building code regulation are strategies in Germany to achieve success of smart green solutions. Both strategies can follow the way either to ecological and/or social effects to the neighborhood. The return of investment of these additional costs is after about 10 years, the benefits will be active over the full - life span of the building.

As an example of technical regulation instruments, the rain tax has been a successful method to implement extensive green roofs in Germany in the 2000's. In the following years, experience similar started in many other countries. Further smart solutions of rooftops are roof gardens, such as rooftop farms. These concepts start first as special design for biodiversity, as private or communal garden areas. Green roofs are instruments to reduce the lack of open green urban spaces within high density urban areas. Methods to incorporate roof gardens in neighborhoods are connected with new models involving stakeholder participation to offer more and bring opportunities with participation procedures, finally with a high acceptance of final solutions. The pros and cons of the various strategies of installation and participation will be highlighted and related to the range of maintenance cost and private and environmental benefits. The presentation will be concluded with some best practice and case studies from selected German cities.

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Developing urban green infrastructure strategies along a double helix of research and practice – Insights from two research projects

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The complexities inherent in planning for green infrastructure necessitate a broad range of stakeholders for its planning and implementation. This includes policymakers and practitioners from different disciplines but also scientists, among other stakeholders.

Transdisciplinarity is now also encouraged or even stipulated by European and national funding agencies for research on green infrastructure. However, ensuring successful exchanges between partners, especially between scientists and policymakers, is often fraught with difficulties.

We present two projects on green infrastructure strategy development—one sponsored by the EU (GREEN SURGE, FP7, 2014-2017), and the other by the German Federal Agency of Nature Conservation ("Green Infrastructure in Urban Areas", 2016)—which include

science-policy interaction as a fundamental aspect. Both projects are based on collaboration and feedback loops between scientists and practitioners, following a double helix-approach. We will discuss the different forms of collaboration used in the research such as interviews, workshops, evaluation and reviews, and how these interactions helped to develop hands-on green infrastructure strategies, as well as challenges of these approaches. We will also present tools to disseminate the developed strategies such as a guide book, checklist and strategy booklet and give recommendations for science-policy cooperation in future research.

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A review of policies and tools for implementing sustainable urban drainage systems in urban planning

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There is a rising demand for the provision of ecosystem services and functions in cities, especially when looking at the context of increased urban flood risk levels associated with climate changes and urbanization processes. This requires a shift from planning approaches that rely on conventional systems and devices, to those aimed at transforming the

eco-hydrological footprint of the city by using nature.

This paper reviews different approaches concerning the adoption of sustainable urban drainage systems by grouping and examining various policy tools (regulatory instruments, market-based incentives, educational and training programs) that stakeholders, both public and private, use at the local level. Examples of these tools, employed across international cities, are reviewed to explore the current state of art, what has been done and what may offer new possibilities to encourage a real transition to a more sustainable management of

storm-water in cities. By comparing experiences that promote a nature-based drainage approach to steer urban transformations, the paper discusses possible trajectories of the ecosystem-adaptation-based decision making processes. The paper also analyzes barriers, challenges and lessons learned about the implementation of sustainable urban drainage systems in both new and existing urban developments.

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Bridging biodiversity conservation objectives with landscape planning through Green Infrastructures: A case study from Sardinia, Italy

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A fundamental definition of Green Infrastructure (GI) was provided by the European Commission in the Communication "Green Infrastructure: Enhancing Europe's Natural Capital", where GI is regarded as a network having the Natura 2000 sites at its core, able of delivering numerous Ecosystem Services (ESs), and "strategically planned", stressing the importance of GI in integrating ecological connectivity and conservation, and

multi-functionality of ecosystems. Consequently, the spatial identification and management of GI is an important issue in planning, and especially in landscape planning as understood in the European Landscape Convention.

Building on a previous work by Arcidiacono et al. (2016), this paper tests a methodology whereby the spatial configuration of a GI is identified in relation to four aspects that summarize the multifaceted character of landscape. The first, conservation value, considers the presence of habitats of community interest (i.e., listed in the "Habitats" Directive, 92/43/EEC); the second, natural value, accounts for biodiversity's capability of delivering ESs; the third, recreation value, is a proxy for people's perceptions of landscape; finally, cultural heritage value takes account of the interactions between natural and human factors. The methodology is tested in the Italian region of Sardinia, by applying it in the coastal landscape units defined in the Regional Landscape Plan currently in force which overlap the metropolitan area of Cagliari. This methodology can effectively help integrate biodiversity conservation objectives into spatial planning by implementing article 10 of the Habitats Directive, stating that relevant features of the landscape should be managed so as to improve the ecological coherence of the Natura 2000 network.

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A green infrastructure in the Metropolitan City of Cagliari: ecological corridors as connections between Natura 2000 sites

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An important set of Ecosystem services (ESs) delivered by green infrastructure (GI) is based on habitats and species protection and enhancement, that is on maintaining and improving biodiversity. Indeed, the second objective of the European Biodiversity Strategy recommends that ecosystems and their services are maintained and enhanced by establishing GI and restoring at least a 15% of the ecosystems which show up significant decay. From this perspective, habitat fragmentation can be considered one the most outstanding causes of a decreasing attitude of GI towards the delivery of habitat-based ESs, since it weakens the capacity to deliver such services by undermining the networking potential of habitats.

In this paper, we propose a study concerning the Metropolitan City of Cagliari which includes seventeen municipalities into a unique system of metropolitan government. Sixteen Natura 2000 sites (N2Ss) are located in the City, which amount to about 30% of the metropolitan area.

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The ‘‘Zero Pesticide’’ objective for cities of Paris Region

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In France on January 1st, 2017, public managers will be prohibited from using phytosanitary products and biocides derived from synthetic chemistry for the maintenance of roads and streets, green areas, forests and walking or hiking trails accessible or open to the public.

However, biocontrol products ‘‘harmful to the environment’’ will still be available for use. Natureparif, the regional agency in charge of nature and biodiversity in the Île-de-France region, has produced a "zero pesticide" indicator following a survey adressed to cities and invites the local communities to step beyond legal obligations and avoid the use of this product category as well.

As of March 2016, out of the 1281 municipalities making up the Île-de-France region, more than 4 out of 5, including Paris, have responded to the survey (82%). 18% of Île-de-France local communities have an outstandingly exemplary track record and apply the ‘‘zero pesticide’’ rule in all of the areas under their management (i.e. 231 municipalities out of 1281 and 2 ‘‘Départements’’ out of 7). 19% use pesticides only in the constraint-inducing areas (sports fields and cemeteries).

Looking only at the municipal data, which are robust due to their large numbers and the high response rate, trends between the various usage categories appear to have evolved in a positive way since the last publication of the indicator in 2014. 37% of municipalities are now at least at a zero level of pesticide use on roads and ways and green areas, i.e. more than a quarter, against 21% in 2014 (i.e. a 76% increase). Since the first publication of the indicator in 2012 (see also the 2014 indicator), substantial evolutions have been observed in the practices implemented by local communities with regard to the use of pesticides.

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The nature-base solutions and green infrastructure at landscape scale – searching for territorial resilience. Application to Portugal

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The green infrastructure concept (GI), defined as a network that gathers the most sensitive and important ecosystems of the landscape, is deeply related to the Nature Base Solutions (NBS), which depend on the knowledge of how nature works. At large scales of intervention, the landscape plans with an ecological-based approach are also planned actions that integrate the knowledge of nature processes and functions. These actions will ensure landscape resilience and improvement of ecosystem services quantity and quality.

This work intends to show how an ecological-based approach in landscape planning at

large-scale can be considered a Nature-Based Solution, as an umbrella structure for planning. In the presented work, it is mapped a proposal of National Ecological Reserve (REN), at a national scale, which is mandatory at municipal scale in Portugal since 1983. The current legal framework that regulates REN states that at a national scale it is only necessary to have a strategic approach. It is our goal to provide a proposal that involves the awareness of ecological base-planning, not only in a strategic view, but specifically located in the landscape, assuring the efficiency of its implementation at regional and local scales. With this proposal, it was possible to define different land uses according to the ecological characteristics of each area, gathering a group of potential land uses that will not compromise the landscape ecological equilibrium. The evaluation of current land use allowed identifying that 52 % of REN needs to be the object of specific restoration programs, both in rural and urban landscapes. This will also provide an efficient planning of GI since the REN framework was considered by a European Union expert group as an example of a GI.

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Green Infrastructure and regulating ecosystem services. A case study concerning the Metropolitan City of Cagliari and the Natura 2000 network

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Green infrastructure (GI) is defined as a strategical planned network of natural and semi-natural areas which can relate green spaces in rural and urban, fresh water, coastal and marine areas. Furthermore, Ecosystem Services (ESs) are the material and immaterial benefits that people obtain from ecosystems; according to the Common International Classification of Ecosystem Service (CICES) definition, ESs include provisioning, regulating, and cultural services. In our opinion GI can contribute to the biodiversity conservation and providing ESs.

In this paper we deal with the role of GI in improving ESs functions and benefits, specifically regulating services referred to soil functions, such as carbon sequestration and water purification. Carbon sequestration means the capacity to accumulate or to release carbon; water purification means the capacity to filter out and decompose organic wastes introduced into inland waters and coastal and marine ecosystems. Hence, we propose a case study concerning the coastal context of the Metropolian City of Cagliari (Sardinia, Italy), overlapped by Natura 2000 sites by the thirty percent of its surface. In particular we focus upon three sites: two mainly forested sites (one in the East and the other in the West side) and a wetland area (in the central part). For this purpose, we analyse an approach to assess carbon sequestration and water purification, identifying potential green infrastructures between Natura 2000 sites in the metropolitan context.

The aim of this paper is to describe the relationships between GI and ESs in a mutable context, as a metropolitan context, concerning the overlapped Natura 2000 network. This kind of knowledge helps to inform decisions and drives planning processes towards the sustainable urban development.

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Urban and periurban forest related research in Mediterranean: A systematic review

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Mediterranean region is characterized by remarkable landscapes and diverse environmental conditions. It is facing many challenges at the moment such as increasing urbanization and urban sprawl, climate change, threatened biodiversity, invasive species, forest fires, water scarcity. These challenges affect quality of life of increasingly urban population. Urban forests as part of the broader concept of green infrastructure with its various ecosystem services and multiple benefits contribute to improvement of human living conditions. However, so far there is no systematic review about the state of the art of urban forest related research. Therefore, the purpose of the study is to provide such overview based on the SCOPUS search. We employed SCOPUS search based on the combination of key words and ended up with more than a thousand hits. Search results were than filtered for relevant papers that were than inserted into database. Main goal of the exercise was mapping of urban forest related topics, identifying the gaps and pointing to research needs. The results are expected to provide guidance to researchers, practitioners, policy and decision makers to be able to tackle various challenges Mediterranean region is facing now and in the future.

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The metabolism of political and scientific concepts aiming to promote and govern green urban infrastructures

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Urban areas are facing global challenges due to urbanisation and climate change. Urbanisation leads to denser urban areas and urban sprawl, which cause losses of natural areas that negatively affects biodiversity and a number of functions produced by ecosystems. Climate change induces challenges related to storm water treatments, heat waves, which can impact inhabitants as well as business in urban areas. Additionally, physical changes in the urban matrix may lead to changing socioeconomic patterns and new political and governance challenges.

To handle urban challenges different types of concepts aiming to grasp different aspects of these challenges have been developed such as, ecosystem services, green infrastructure, nature- based solutions, ecosystem based adaptation, collaborative management of natural resources with different aims and ambitions. The concepts have links to different research disciplines as well as to different political and practical contexts. As a consequence when actors from both policy and the scientific community aim to interact and develop management structures misunderstandings are common. To assess both the origin and development of the increasing number of concepts this paper map the concepts and their content and relationship to scientific disciplines, as well as if and how they are used as boundary objects, to communicate meaning in relation to the understanding and management of green space in an urban context.

The article is based on a literature review of scientific articles on urban green areas. The results indicates that different disciplines and practices have relatively independently developed concepts aiming to understand and promote urban green space focussing on different aspects and functions of what is meant by green, as well as having different relation to the built urban environment. The article ends with a reflection on how the affiliation of these concepts to different disciplines and practices may affect ambition of trans disciplinary based management of the green urban environment.

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SESSION 8
Science-policy implications of GI

POSTER

Guidelines for Sustainable Urban Forestry of Roma Capitale

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ISPRA - in collaboration with Roma Capitale – has issued the "Guidelines for Sustainable Urban Forestry of Roma Capitale" with the aim to support sustainable urban forestry through scientifically-sound and technically viable approaches, and to provide a technical reference frame for green infrastructure policy implementation and assessment, which should be sustainable from an ecological (biodiversity conservation, etc.), social (participation, safety and health, etc.) and economic (efficient resource use, landscape beautification, etc.) points of view. Guidelines provide technical recommendations for planning (forestry project, site selection, planning addresses, selection of species and propagation material) and realization of forestry interventions particularly aimed at carbon sequestration, mitigation of air pollution and noise control, biodivisity and improvement of ecological connectivity.

Guidelines support decision makers in planning and creation of new urban and periurban forests, following a planning finalized to reduce ordinary maintenance and to avoid wastefulness of resources such as water and energy.

The success of forestry interventions crucially depends on how it is integrated in the territorial context. New green areas, in fact, should be planned considering their integration in the urban context, so to be significant in the ecological connectivity. A careful planning and, primarily, the appropriate species selection, allows to optimise costs and to successfully pursue specific objectives such as carbon sequestration, improvement of air quality and biodiversity protection

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How green is a “Green City”? A review of existing indicators and approaches

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More than half of the world’s population currently lives in the cities and consequently urbanization has been among the major drivers of global environmental change. The fast urban growth, likely to result in a share of 75% of people living in cities by 2050, has resulted in development of cities which are unfriendly to people as well as to the environment. As a contribution to reverse this trend, various institutions have organized competitions between cities ranking the degree of their “greenness,” based on quantitative and qualitative indicators accessing economic, social and environmental performances. Most of these competitions have been conducted only once and the studies include different cities because their attendance was voluntarily. We analyze the potential of city rankings to contribute to a positive development of cities. In the first part we defined the “Green city” concept comparing the definitions in the literature. Three keywords are identified that characterize a “Green city”: the "environmental quality," the "human well-being,” and the “political and social action". For measuring the “greenness” of cities, we analyzed the urban indicators of four popular indices, representing 13 categories which were then grouped into the three "Green city" dimensions. Regarding “environmental quality” and “human well-being,” quantitative indicators are used while qualitative indicators seem better suited to define the “societal and political action.” By monitoring the quantitative indicators over time, we are also able to assess the “Green city” performances and at the same time verify the effectiveness of “social and political action.” The use of quantitative and multidimensional indicators can be a valuable tool for urban governance and planning.

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SESSION 9
Economic impact of GI for resilient and sustainable cities

ORAL

Keynote Speaker
New governance and finance models for urban regeneration

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With urban populations growing, public needs for infrastructure such as water, energy, public transit, affordable housing and waste management grow as well. At the same time, many older cities have legacy infrastructures (e.g., roads, energy) and under-utilized areas (e.g., former industrial and harbor districts) that need to be remade for a radically changed economy. With public finance budgets overstretched and increases in taxes often contentious, government at all levels is challenged to finance these efforts. This session explores the different ways in which first mover cities finance and govern urban regeneration towards more sustainable cities, including deploying new institutional vehicles and innovative finance mechanisms.

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Economic valuation of Urban and Peri-Urban Forests Recent trends and evidence from Europe

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Within the European Union, the concept of multi-functionality is utilized to emphasize on the many services which Urban Forests ("UF") and, more in general, Natural Capital display in addition to their prime purposes related to commodity outputs (Millennium Ecosystem Assessment, 2005). As a result, UF is less put into the context of the production of goods, but rather into the context of natural resources' protection, spaces for leisure, education, health and wellbeing, cultural and heritage landscapes (i.e. Ecosystem Services).

The recently emerging "Green Infrastructure" approach is characterized by the recognition of the full range of economic, social, cultural and environmental functions and benefits (Green Infrastructure (GI) (COM(2013) 249 final). The economic implications, in particular, are increasingly focusing researchers, policy makers and practitioners' attention from new perspectives, mirroring the needs and claims of the growing population of urban dwellers.

Landscape architects, planners, and urban foresters have started incorporating metrics and performance standards as an emerging part of best practice mostly throughout North America and Europe, but also in Asia and Africa. Numerous theoretical and technical tools have been developed to understand different economic valuation aspects, adapting methodologies and designing new frameworks, especially in the emerging research area of the landscape economy. Better understanding of economic values, associated with planning, design and management strategies and practices, opportunity costs and ecosystem functions and services, enables decision makers to successfully engage in trade-off analysis and to identify the potential benefits and losses associated with specific urban landscape governance models.

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Economic evaluation of green roofs installation in buildings

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Green roofs have been proposed as an efficient tool to combat urbanization problems, as they can help achieve sustainable built environments and improve buildings performance. This paper compares the life cycle of green roofs with the alternative scenario of traditional roofs at 3 levels: financial, economic and socio-environmental. The analyses are performed both at a building and city scale. The financial level balances the construction, maintenance, replacement and demolition costs with private benefits such as discount on fire insurance, energy consumption, improvement of photovoltaic performance and urban rooftop farming. The economic analysis also includes the economic gain associated to the increase of property value, aesthetics, recreation and sound insulation. The social-environmental analysis adds social benefits related to storm water management (water quality enhancement and flood risk control), noise reduction, air pollution removal, mitigation of urban heat island effect, public health, ecological preservation and job creation. City built environment was characterized taking into account building age and use, roof type, and state of conservation. The study confirmed the long term economic feasibility of green roofs at a social level but not at a private level. The net present value of the implementation of green roofs in Lisbon is of about 3.430 million Euros. A sensitivity analysis was also performed showing that property value, aesthetics, recreation, sound insulation, discount rate and air quality are the key parameters for green roofs retrofit in buildings.

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The influence of Urban Green Spaces in local economy: Lisbon (Portugal) as a case study

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Urban green spaces (UGS) valuation is a major issue in city planning and decision-making. This valuation can be performed by looking at the ecosystem services (ES) they provide, a frontier framework that can include the linkages between economic, socio-cultural and ecological values. In Lisbon (Portugal) the municipality has been focusing on the valuation of UGS for the revitalisation of the city. In this study, we evaluated if Lisbon's UGS are perceived as attraction elements, either for business establishment or for the valorisation of real-estate, considering different areas of the city. We measured business distance to the closest UGS, the UGS area in two buffers (50 and 100m) around businesses, and the average housing sale price/m2 per parish. Results showed that only "kiosks cafes" were positively associated with UGS presence, demonstrating an association between UGS and the cultural value of kiosks, highlighting their recreational value in greener areas. Housing sale price did not show associations with UGI, presenting, however, a significant association with several business types. According to these results, UGS seem not yet to be considered top attraction elements, neither for business in general, nor for the valorisation of real-estate. Moreover, businesses and the average housing sale price/m2 are associated to specific areas of the city: Lisbon's historic and city centre presented higher numbers of business and housing sale prices, which may be explained by the city's rich cultural and historical legacy. Nevertheless, considering the ES that UGS provide for human well-being, it is important to divulge services provided by UGS and to value these in economic terms, contributing to the improvement of the city's local economy.

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Translating greenhouse gas and energy savings in to saving money at NYC department of transportation

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In efforts to make the city more energy efficient and sustainable, the New York City Department of Transportation (NYC DOT) has been implementing energy efficiency projects that are projected to save over $20 million annually in energy and maintenance costs. The NYC DOT works in accordance with the City's sustainability plan to reduce greenhouse gas (GHG) emissions 80% by 2050. Projects currently underway include converting all of the City's Streetlights - over 250,000 - from High Pressure Sodium to LED and installing solar panels on roofs of our buildings. The NYC DOT also participates in the citywide Demand Response Program, which requires the Agency to cut energy use during times of stress on the electrical grid. Participation in the program is rewarded with financial incentive payments from the utility, but also reduces peak load and energy costs for the facility. While the City's main goal is focused on reducing GHG emissions, we are also dedicated to reducing energy and maintenance costs for the agency.

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Comparing the costs of grey and green infrastructure in Paris region

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Nature-based solutions (NBS) in urban context can be defined as solutions inspired and supported by living systems to address conception or management issues in cities. It can be distinguished from Technologic-based solution (TBS) which rely mostly on technology.

NBS and TBS are not in opposition as they can be both combined at different level. In the context of biodiversity loss and climate change, NBS has proven to be efficient for its multifunctionality, such as water management, carbon storage, biodiversity enhancement, cultural aspects, whereas TBS often address one purpose at a time. Beyond technical aspects, it is important for local stakeholders to be able to compare the costs of different type of solutions. To address this issue, we conducted a study on 3 cities in the Paris region: Chauconin-Neufmoutiers (2 754 inhabitants), Montreuil (103 068 inhabitants) and Nanterre (89 476 inhabitants). We first identify grey infrastructures that could be replaced by green ones, as well as different green options. We finally compared the global cost of all these option (including conception, management and end of life). For example, we compared water management options as well as urban heat island mitigation options or green space management. In every case, we show that NBS are less costly than TBS, or as costly for one example. This confirms that NBS as part of a green infrastructure strategy can help cities to reduce public expenses while promoting green jobs. We pointed out the need for complementary studies that could help design policies towards green infrastructure.

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A flexible multi-scale system dynamics modelling framework to assess the socio-economic impact of urban GI

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The uncertainty of climate change, the fast-growing increase of global (urban) population and, as a result, an intensified competition among urban land uses demand a transition towards spatial planning models that maximise resilience, sustainability, and land-efficiency of cities.

To succeed on this transition, more rigorous, holistic, and flexible assessment approaches of Green Infrastructure (GI) are needed: i) to define better their economic costs, benefits (i.e. ecosystem services), and losses (i.e. ecosystem disservices); ii) to facilitate comparability between options (including *grey* alternatives); iii) to adapt their valuation to different context, socio-economic scenarios, and implementation models; iv) and to easily inform stakeholders and decision makers. To this end, we introduce a flexible multi-scale system dynamics modelling framework that can assess the socio-economic impact of urban GI (its ecosystem services and disservices) in a monetary and well-being value scale. For the monetary value scale, data from life cycle inventories, input-output models, and other process-based parameters of the system dynamics modules are translated to impact scores. This is done by calculating the marginal product of ecosystem services in both an economic production and a welfare function as an estimation of the shadow prices of each service. The practicality of this framework to support urban planning decisions will be outlined through a methodological advancement's roadmap, framed in the context of a current international project on re-naturing cities (*Nature4Cities*). Additionally, examples of previous cities and neighbourhood proposals will be used to show how our modelling approach could better inform future urban planning works.

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SESSION 9
Economic impact of GI for resilient and sustainable cities

POSTER

Greening Urban Transport Infrastructures: methodologies to assess technical and socio-economical feasibility

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Driven by several EU Commission directives, national and local governments are forced to rethink urban environments and find solutions to the noise and air pollution problems generated by busy traffic routes, which often disconnect communities. Improvement projects such as decking over freeways and rail tracks with green roofs are innovative alternatives to relink the city, add new networks (bike paths), increase parkland and permeability.

Additionally, such large-scale green roofs can help mitigate well-known environmental problems of urban areas. Design solutions and performance are influenced by geographic and meteorological conditions, so cost-benefit analyses of greening urban transport infrastructures for better informed decision making are needed to rank alternative solutions, quantifying externalities in a global socio-environmental cost perspective. Two case studies are presented in this paper, one studying the alternative of introducing green roofs decking an underground highway and other associated to the introduction of green roofs and/or green walls in public buildings, e.g. stations or rail yards. Positive impacts such as CO2 absorption, acoustic and thermal behaviour, rainwater retention, urban fabric relink, creation of new land and biodiversity are balanced with initial and maintenance costs as well as urban mobility and transport operational effects. Native plants are selected to minimize irrigation and maintenance.

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SESSION 10
GI in future urban planning

ORAL

Keynote Speaker
The idea of landscape: new ways of delivering Infrastructure

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Overlooking the Visual, Demystifying the Art of Design (2010) (OTV), offering a redefinition of the relationship between the senses and intelligence, argues that perception is not just close to intelligence, but *is* intelligence and this is what challenges the prevailing rationalist paradigm. It allows us to work independent of the idea that we need to engage or leap between different modes of thinking, constrained by the notion that there are fundamentally different types of truth or pre-linguistic starting points of thought. Having significant implications for the way we think about consciousness, the landscape and the design process, this provides a different philosophical agenda for theory, a strong conceptual basis for arts education and establishing the *idea* of landscape as the social/physical/cultural context of our lives, it lays the ground for a much broader field of design practice.

This paper will examine the challenges of this more expansive, interdisciplinary approach for the delivery of infrastructure, arguing that there is a clear need for a fresh look at landscape, a new philosophy with identity at its core, an innovative approach to the understanding of design as a critical, artistic practice and a holistic view of the landscape as the context for the processes of development – whether this informs the design of policy, regional transformation, city master-planning or the management of forests, parks and squares. Moving inquiry into the more ambiguous realm of ideas and expertise, it is evident that whatever the discipline, what is absolutely critical is the manner in which we practice – not simply the materials we use. It considers the implications of this approach through examples of a number of projects in the UK including HS2, the £52billion high-speed rail link between London and Birmingham, Thurrock, North Warwickshire and Church Street, London.

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Greenprint For Cities – Delivering Green Infrastructure

*Tom Armour**
ARUP

We now have array of policies, protocols and projects that our sector has helped to develop and deliver including work by the EU on nature-based solutions. But most would admit we haven't been as successful as we would have liked in terms of enacting them and we need to do more to bring green infrastructure into the mainstream – as a critical infrastructure that is planned and designed as other city infrastructure systems including energy, transport, water and waste. Most indicators show habitats and species continuing to decline at alarming rates, health problems continuing to get worse, especially in our cities and urban areas, and the impact of climate change on the increase and creating unacceptable and intolerable conditions for many in our cities and urban environments with the economic costs of this on the increase.

We know that the natural world, its biodiversity and its constituent ecosystems are critically important to our well-being and economic prosperity. We know too that it is consistently undervalued in conventional economic analyses and decision making and in the planning and design of many urban strategies and projects. Powerful and growing global research in this area is delivering an understanding of the significant social, economic and environmental benefits of green infrastructure in terms of its multi-functional qualities to; a) engender health and well-being for people and biodiversity and: b) tackle the effects of climate change.

A critical challenge therefore, is how we can more successfully deliver greener infrastructure. Delivering more will provide more exemplars, examples and case studies where benefits can be measured to persuade a greater move towards nature-based solutions as the mainstream way of carrying out projects. Using examples from around the world this presentation examines how we can better deliver and implement green infrastructure projects.

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Botanical city-the urban desert turned into an oasis- Habitat and Urban Greening Processes / Models / Strategies / Tools / Landscaping

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Botanical city is an essay that reveals the shortcomings and limitations of the historical paradigm in Landscaping —associated to Modernism— in providing answers to environmental and social problems of the contemporary post-industrial megalopolitan territories. It offers a new approach that involves the need of material and symbolic intervention in the cultural landscape. Faced with the prospect of environmental and social risks, urban greening would be integrated into an environmental strategy aimed at the creative invention of postindustrial city, in an alliance of biology and social construction of landscape. Current trends suggest that 60% of world population will live in urban areas by the year 2030. In that context, and as a conceptual and pragmatic objective, Botanical City proposes biocenosis to build the urban artifact. A green skin as biotope that provides continuous mitigation and bioclimatic urban enhancement, energy saving and ponderable environmental services for a higher quality of life in more sustainable cities. In short, a landscape design contributing to the humanized reconquest of the urban space, regarded as the public space, where integration and social inclusion takes place.

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The City that feels and functions like the wood

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The city that feels and functions like the wood has become the vision for climate-adaptation and sustainable development of urban landscapes. While this city is still a vision, cities are in fact very wooded. Woodland fragments constitute the most frequent type of green space (in terms of square meters) in many European cities, and climate adaptation experts have started to ask for 'mitigating design solutions' where parks and other types of green spaces should feature more woods in order to infiltrate storm water and mitigate urban heat island effects more effectively than non-wooded green spaces. This development urges urban professionals to move discussions away from how urban green space and infrastructure 'should' look like to how they 'could' look in the future. Drawing from two decades of experiments in the Scandinavian landscape laboratories, the presentation outlines and exemplifies how conventional design and management of woodlands, parks and gardens can be merged into new perspectives for designing urban landscapes under, in and with tree canopies. Perspectives where woodland do not stand in opposition to other types of green space, and where the conceptual approach to design of parks and other types of urban green space is reversed from 'adding trees to an open canvas' to anticipating a 'fully tree covered canvas' from which trees are removed only when absolutely needed; e.g. 'rain forests' replacing rain gardens because they too retain and evaporate storm water but mitigate urban heat island effects more effectively. And 'pocket woods' replacing pocket parks as the next trend for 21st century urban landscapes.

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Small-scale green infrastructures: a literary review of the future of urban green spaces design

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The vulnerability of the conventional piped drainage system is showing with a yearly frequency in many areas of the world.

Resilience to clime change of urban areas has therefore become a huge research theme in the scientific community. Since its complexity, such theme has been approached from many different angles: planning, design, ecosystem services, etc., but Green Infrastructures (GI) represent a common feature.

What still lacks, is a clear understanding of the multiplicity of elements that can be included in the GI's category, in order to cope with a neighbourhood scale approach to planning and design.

The aim of this work is to provide a review of the most common design features that fall into the small-scale GI's category, their pros and their cons, their application fields and their relevance in the future of green spaces' design. This is an important task since some of these design features are more widespread diffused and studied, such as green roofs. On the other hand, some others, such as storm-water tree trenches or curb extension, are far from being common in many urban contexts.

The real strength of GI is when they are vastly applied and when they can work in synergy with each other, being part of a more complex system than just one feature.

Many of the addressed GI operate in a very similar way to many infiltration features (infiltration, storage, evapotranspiration etc.) but they can offer a supplemental tree canopy, with all its subsequent benefits.

The main benefits that GI can provide are: reduced runoff, increased amount of storm-water managed, improved growing environment for plants, helping in the removal of several chemicals including metals, organic compounds, fuels, and solvents, increased biodiversity, reduced UHI (Urban Heat Island).

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Four perspectives on the future of nature in European cities

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Pro-nature actions can contribute to the challenges of EU's Urban Agenda to create adaptive, inclusive and sustainable cities. For example, more accessible green areas provide social benefits, as nature offers an environment for interaction between different social and ethnic groups. Or green spaces in cities can reduce heat stress and air pollution.

But what is 'nature', what does this mean for the transformation of cities and who are to act? Urban planners and nature managers often think in terms of one unified nature, whereas multinaturalism is a more appropriate approach to capture the different ways people understand and appreciate nature. Broadening the notion of nature may differentiate the repertoire of practices. Cities would benefit from a greater citizen and business engagement in the implementation of actions.

With the aim to inspire strategic debate on nature policy and spatial planning we have developed interactively four perspectives in Europe: Strengthening Cultural Identity, Allowing Nature to Find its Way, Going with the Economic Flow and Working with Nature. Each departing from a different set of guiding values. We have analyzed how nature would look like and which governance would fit.

The perspectives show various spatial strategies in green infrastructure development that could contribute to addressing the urban challenges. The spatial strategies can be applied to realise nature-based solutions and to increase accessible nature at the doorstep. Coalitions of various actors, such as private citizens, real-estate developers, water managers and urban planners can use these strategies to tackle the urban challenges. Coalition composition may vary, depending on circumstances and on the strategy pursued.

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Re-thinking the peri-urban Realm. Soils, Land Uses, Landscape Connectivity

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Since 1990s, the European Sustainability Agenda has indicated in the ecological connectivity the common ground towards biodiversity, natural and landscape values safeguard, soil defence, environmental resources regeneration and performance improvement.

Two approaches stand out for their innovative content. The first one, inherent to architectural disciplines, levers on the tradition of urban design in order to figure out settlement patterns able to decline sustainability even as a "Good City Form". The second one, from the outside and namely from the corpus of the natural sciences, incorporates ecological principles into regional and urban planning.

The Green Infrastructure approach is located at their convergence. EU strategies particularly indicated to treat low density areas and urban fringes, nowadays the majority of our habitats. The proposed contribution addresses relevant pilot experiences in Germany, France and Italy, with different declinations. The multifunctionality of the eco-agricultural connections is at the core of an attentive discourse among planning instruments and policies. In France, a legislative framework sets the ground for regional and urban planning dealing with GI at different scales. In Germany, urban regeneration instances are associated with energy and climate change challenges. In Italy, the GI concept is being introduced prompting case-by-case yet punctual answers even at the local level.

Such approaches, surveys and experiences involved in GI relate intrinsic soil fragility and productive potentialities. They provide connections between spontaneous renaturalisation and new life cycles of derelict and dismissing lands in the periurban wide textures, dealing with spill-over effects between new and traditional landscapes.

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Is land well-taken? Linkage between urban green spaces and new built-up areas

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Urban green areas (UGAs) are widely recognized as basic elements for Nature-Based Solutions (NBS), as they may preserve and increase environmental values in urbanized contexts supporting a wide range of ecosystem services provided to citizens. Accessible and usable UGAs are therefore important indicators of environmental quality of urban settlements. In particular, given the current trend of urbanization, the availability of UGAs accessible from the new buildings is an important issue to be considered in the sustainable governance, management, and design of metropolitan areas. In such a context, the present study aims at assessing accessibility and usability of UGAs from the recently established urban settlements of the 15 administrative units of Rome's municipality, considered as an exemplificative case of Mediterranean city where urban sprawl occurred in recent decades. Firstly, we used the European Urban Atlas geodatabase to identify and map areas where urban development occurred between 2006 and 2012. Secondly, we performed a network analysis to assess the distance of new settlements from the closest UGA. Ancillary data were also used to estimate the usability of UGAs. Around 90% of UGAs resulted usable. More than 60% of new built-up areas have a UGA within the first kilometer.

The proposed methodology can be replicated in similar contexts being useful for urban planners and decision makers (i) to support the assessment of the quality of life of people living in the recently established settlements; (ii) to design new UGAs in order to increase the value of new built areas. Implications, future perspectives and needs for sustainable urban planning in the light of NBS perspective are reported and discussed.

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GREEN URBAN REGENERATION. The application of the "*B.A.F.MO"* index for the improvement of environmental and ecological quality in an industrial area of Modena

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Urban regeneration is an operation of sustainability that must start from the identity of the place. Tools that can play a fundamental role in the requalification and regeneration of our cities regard both the adoption of innovative urban and environmental policies and the application of technologies and design solutions that increase the sustainability and environmental well-being. To this end, an environmental index was identified that is able to reduce the construction impact and at the same time promote green in urban areas. This index was applied to one of the most densely built areas in Modena: the industrial area Villaggio Artigiano, a place that represented for the city the powerhouse of wealth and well-being and today is a place of strong identity value. The Index is based upon the *B.A.F.* ("*biotope area factor*") used in several European cities, amended and adapted to the requirements and characteristics of the specific location (*B.A.F.MO)*. The motives that led to the determination of this urban index are mainly the following: the possibility of having available an efficacious tool for environmental mitigation and balance, the improvement in living spaces and economic benefit from energy savings. Useful environmental mitigation and balance tools are the integrated application of technologies for the management and recovery of rainwater with the realisation of green surfaces (roof gardens, green-walls and traditional green), as well as the advancement of interventions for low CO2 emissions and the resilience to climate change.

Regenerate signifies not only giving perceptive, residential and industrial dimensions that permits a greater well-being formed upon society's desires but also adopt procedures and solutions for a real improvement in the environment.

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Creating the edges- a landscape context of green infrastructure in an urban boundary

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The study focuses on an urban fringe zone and complexity of roles performed by its green areas. It highlights the importance of greenspaces' impacts on the urban boundary and edge structures. Since the work employs a landscape perspective, ecological and aesthetic dimensions of the issue have been incorporated.

The urban fringe not only constitutes a zone of transition between urban and rural land use, and the 'planning's last frontier' (Gallent *et al.*, 2004), but also a distinct landscape (Gallent *et al.*, 2006; Qviström, 2007). Hybrid, disturbed, transitional faces serious environmental and spatial problems, being simultaneously the reservoir of important ecological resources and services for the entire urban system. A lack of spatial order and aesthetic depreciation of places belong to the most pronounced concerns of the examined landscape. Noteworthy, although the fringe with its edges determines composition and the image of a town, these functions are rarely analysed and relevant problems seldom resolved. As the research reveal, urban greenery (embracing urban forests) possesses a great potential for counteracting the landscape-related problems of the urban fringe. Predominantly, the potential consists in a strong influence on spatial structure, and it exceeds the Green Belt long-established nomination. Green areas can enhance the degree of naturalness, provide an organizational pattern of space, mitigate ecological and aesthetic contrasts- in consequence, they can raise landscape values and attractiveness. With respect to the necessity to improve a spatial order, both an inner and outer parts of the fringe are examined. A construct of the soft, gradual, transitional zone is proposed as far as the shape and composition of the urban boundary zone and its edge is regarded. Furthermore, a pattern of a natural ecotone is featured owing to its ability to ameliorate the outer edge of the urban fringe.

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Landscape strategies for the implementation of a green network in the cityscape: a concept for the design of the open spaces of the Alma Mater University (Italy)

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The study shows how the open spaces connected to public or private education institutions, within in the complex urban morphology, represent green resources with a great potential for the implementation of a green network. As a whole, within a unitary project, they can have positive effects and contribute to reduce a widespread urban disharmony, with benefits for the overall urban landscape quality.

The work aims at promoting planning and design strategies for a built environment consistent with the cityscape. Therefore we present a point of view and a pilot case focused on the definition of guidelines for a sustainable and unitary project of the open spaces of the University of Bologna, located in various campuses in the Emilia-Romagna Region (Italy).

Those places are meant as already existing or potential green patterns, intertwined with the urban weave and the ecological system. They represent a widespread heritage, complex and diversified systems, each one with its own peculiarities and identity, be they the result of historical evolutions or of new developments, located in a historic city center or in recently built-up periurban areas. Their needs and diversified interventions derive from their characterization (spatial composition, scenic perception of vegetation, environmental comfort), and from the study of the relationships (built-up and open spaces, indoor and outdoor spaces) and connections with the cityscape's tesserae (ecological and environmental, fruition and cultural). The green design approach is based on the respect and the continuity whit existing, whether they are natural and anthropic elements, and on low construction, management and maintenance costs, while preserving ornamental and aesthetic values.

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‘Sii The Future’ - The practitioner’s evolving role in ensuring effective delivery of sustainable, integrated green infrastructure in the built environment

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Sustainable integrated infrastructure (Sii): The ever increasing demands on our urban space call for increasingly innovative design and engineering solutions. Recent developments in the supporting principles and technologies provide increased potential to integrate grey, blue and green infrastructure and thereby fully utilise our limited urban space and ensure compatible longevity of its elements.

The benefits of ecosystem services are now well documented with quantifiable research helping to secure nature based solution initiatives. This brings subsequent challenges i.e. their successful delivery and functional longevity. This paper challenges the practitioners responsible for delivery; are their working practices and delivery mechanisms fit for purpose, are they evolving in line with the developments in policy, science and technology? The paper explores the potential and need for a more dynamic response.

Sii is a design concept that evolved as a result of a CABE Urban Design Skills Scholarship in 2010. The research objective (‘to enable the production of best practice guidance in the principles and technologies associated with design, establishment and compatible longevity of trees planted in the built environment’), resulted in the Trees and Design Action Group publication ‘Trees in Hard Landscape’ in 2014. Maximising the benefits that Sii can provide requires multi-disciplinary input at the conception and design stage of urban development. A sustainable and compatible urban treescape must be ‘designed in’ and to achieve this GI practitioners need to better promote themselves as an integral part of this process, making greater demands on researchers, urban planners, product suppliers and policy makers, as well as on themselves

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Green infrastructure experiences from Italian context. A network analysis approach

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During the past decades, the contemporary metropolitan urban systems, which are characterized by necrosis of their social fabric, environmental and cultural institutions, have initiated various regeneration experiments of public space. Such multi-purpose projects were addressed to restore environmental quality and multifunctional redevelopment of depressed urban areas. According to the geographical area and geopolitical conditions, different design approaches are described by a heterogeneous terminology: 'Ecological Network' for northern EU countries, 'Green System' in Balkan area, 'Green Way' in North America, 'Biodiversity Corridors' in Philippines and 'Urban Greening' in Singapore, are only a few examples. The international scientific research is subdivided in classifier and unifying directions. The former engages to define the domains, characteristics and approaches. The later focuses on searching an overall term, that encompasses all terms through the identification of their similarity.

Utilizing the interpretative basics proposed by Ahern (1995), the status of implementation of such practices are defined in the large metropolitan areas of Lazio and Lombardy. Such status will be conducted by classifying GI projects in context, project scale, objectives and strategies. According to the graph theory, the GI networks will be examined to define the distributive characteristics and diversity between the analyzed metropolitan systems, illustrating their strength and frailty.

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Green planning models and future cities: principles for re-naturing cities

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This paper presents an integrated approach to the study of urban and green space planning by examining key planning models able to balance urbanisation and nature. There is today a lively debate about re-naturing cities, since it can address multiple societal challenges and generate benefits such as the enhancement of health and wellbeing, sustainable urbanisation, ecosystems and their services and resilience to climate change. Yet, further consideration of the roles that positive spatial planning and planning models in particular have to play in fostering the integration of urbanization with nature is needed. This paper, thus, focuses on representative models with such potential, including the green grid, green belt, the green heart, the green wedges and the networked city. Initially, it identifies the main aims and characteristics of each of the four first models, concentrating in particular on the distribution of green spaces in relation to the built up areas and urban systems, their main functions and typologies. Secondly, it centres on the networked city model, examining how it presents a hybrid approach intending to maximise the systemic integration of natural and urban systems. Diagrams of the models and examples of their application will be presented. Finally, the paper will establish a comparative analysis of the models studied, offering insights into their potentialities in bridging the city-nature dichotomy and potential future directions of development.

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NBS-BMPs planning for urban runoff control: a study case in a peri urban area in the metropolitan city of Rome (Italy)

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Assessing the interplay between green and grey infrastructure is of paramount importance for the introduction of efficient Nature-Based Solutions (NBS) in urban planning. In this framework Best Management Practices (BMPs) are increasingly being used as stormwater management techniques to reduce the impacts of urban development on hydrology and water quality due to soil sealing. Since urban development and climate change processes have increased their impact on ecosystems and human quality of life, several social-ecological conflicts appeared in both urban and natural (rural) areas. Nowadays, natural ecosystems and rural areas are often impacted by overexploitation of resources and pollution releasements from human activities and urban areas. On the other hand, urban systems highlight a critical lack of socio-ecological sustainability due to increased fluxes of water,

pollutants and energy (i.e. storm water and solar radiation) not more properly managed by traditional grey infrastructure (e.g. pipes, wastewater treatment plants) and densely urbanized surfaces. In this paper, water flux issues are analyzed in a peri-urban area of the metropolitan city of Rome, which is characterized by high criticity of both urban and natural systems. In particular, the interface between residential districts (Casal Palocco, Acilia and Infernetto) and the protected area of Castelporziano can represent an exemplificative study case for the assessment of BMPs relations. High resolution data has been produced for physical and ecological environments. Water fluxes have been then studied by hydrological models and several BMPs proposals have been presented according to hydrological vulnerability, current prescriptions in master plan, physical constrictions, people needs and availability of public open spaces.

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Streetwise

*Laura Moreno**
Starlab

The Smart City trend started some years ago with experimental projects within innovative cities in the world, and, in particular, in Europe. Taking advantage of such innovative trend, several so-called Green Cities are focusing their urbanization efforts in the most efficient and sustainable energy, transportation, and infrastructures possible. We believe Green Cities can go further.

Urban vegetation such as trees and green space provides significant climate resilience, economic, and social benefits is listed as Essential Climate Variables[1] listed by the Global Climate Observing System

The concept of the STREETWISE project is to build and demonstrate the added value of the Green Infrastructure Valuation Framework for climate change resilience and economic valuation of urban forests in cities with the objective in mind to disseminate and promote the implementation of Nature-based Solutions in urban environment.

It will integrate information related to vegetation inventories and distribution from various sources: satellite and in-situ observations. The system will allow visualizing and evaluating the economic impacts of a single tree to the complete urban forest of the city.

First, from Satellite Normalized Differences Vegetation Index maps would be obtained, then GIS processing would estimate green area locations in the city, and then produce tree locations. Tree inventories from public open datasets would be compiled with the previous results to attribute health level to each single tree. The information would be displayed in a dedicated platform designed to support operation planning.

Several cities currently provide open data freely available to provide official information about the city and its infrastructure. Among this datasets, in Barcelona, a tree inventory is accessible, and provide complete information of all the trees in the city including species, and address of each tree. In order to estimate the health level of the urban trees, the centroid database would be combined with the tree inventories. The vegetation index would be then attributed to each single tree.

The objective of the STREET WISE service is to provide information about the Health and distribution of Urban forest at tree level in order to make the management and inspection much more efficient.

The final end users would access to the information looking at the dedicated web platform.

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[1] Implementation plan for the global observing system for climate in support of the UNFCCC - 2010 update, August 2010, UN Environment Programme

Planning green infrastructure solutions for smart cities

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The benefits of Green Infrastructure for urban environments was discussed for many years. Meanwhile it is undisputed that plants represent a key element of smart cities due to their proven multiple benefits as: pluvial flood prevention, urban heat island, air purification, medical and psycholigal effects on citizens and many more.

Numerous cities worldwide released guidelines and regulations to foster the implementation of Green Infrastructure. Still the degree of implementation of green infrastructure is unsatisfactory. A main constraint identified by an international consortium within the European Research Project "Green4Cities" was, that planning of green infrastructures was not integrated in typical urban planning processes and the possiblity to optimize effects towards cost not given.

Together the consortium developed the GREENpass technology to provide a planning and optimzation tool for urban planning processes.

The GREENpass technology comprises of a simulation software, ressource demand analytics, standardized transparent evaluation process tailor made for different urban planning processes. The core engine of the GREENpass technology is a holistic, 3D, high resolution numeric simulation software called ENVI-met. Planning objects, as urban development designs or building plans, are "rebuilt" in the software and objected towards defined climatic framework conditions. The parameters of thermal performance (PET, air temperature, surface temperature, air temperature of outflowing air), windfield, CO_2 uptake, heatflux are determined for day and night. A multiparametric analyse of the examined projects calculates evapotranspiration, irrigation demand, cost for installation and maintenance, waterretention and runoff coefficient. Based on this in depth analyses the planning object can be optimized with regard to the named parameters.

The individual performance of the planning projects is assessed towards thematic fields mesoclimate, microclimate, waterretention, cost and quality. The applied scales are relative, taking into account the different framework conditions worldwide. The results are summarized in a detailed report. Finally, an official certificate is issued to project developers.

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A planning framework to evaluate demands and preferences from different social groups for accessibility to urban greenspaces

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The role of urban greenspaces is widely considered having positive implications for health and providing a complete set of ecosystem services in cities. This paper presents a planning framework to assess the suitability of existing unmanaged open spaces to new greenspaces in high density urban contexts, especially considering needs and demands of accessibility from different social groups (e.g. children and elderly people). A set of indicators as proxies to measure the accessibility to existing open spaces is proposed, combining spatial

socio-economic data derived from census with land-use and road network information, so to take into account existing interactions between social demands, urban environment and the present semi-natural features in cities. Two applications of the framework are proposed for the city of Catania (Italy) and Nagoya (Japan), cities characterized by high density urban contexts and the presence of particulr social groups. Planning implications for the 2 case studies are discussed.

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The Green Local Infrastructure (GLI) in the city in crisis. The Spanish cities and the future planning laws after the housing bubble crash of 2009

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architect

In this paper, we study the problems of Green Local Infrastructure in relationship with urban planning laws in a high urban development with unfinished urban areas and cities in crisis. We study the Spanish case specially the extra-peripherical areas in Madrid.

Spain, from 2009 until today, had suffered a hard economic crisis as results of a housing and banking crash called "burbuja inmobiliaría" in the line of other housing crisis in last years of XX century and first ones of XXI century, for example the USA cities of Detroit and Richmond, the 1990 Swedish housing crisis, the Irish crash of 2006, etc... In this paper, from the Spanish cities example, we study the problems of the Green Infrastructure, specially the Green Local Infrastructure that, probably, will be de most fragile of all.

What we mean with the GLI?

The GLI or Green Local Infrastructure is the equipment that city needs inside the urban perimeter that is connected with the outside General Green Infrastructure (GGI). Is the nearest infrastructure to citizens.

Why we study the GLI in the city in crisis?

In the city in crisis we need to study what to do with the GLI when they remain empty, because they can change urban benefits into a high social risk. So we need to think new answers and new functions for these areas.

And also we have to think new laws that allow changes that enhancement the GLI when the city falls in crisis and with the shrinking cities.

The problems of a high rate of urban growth and the future of GLI in vacant urban areas in Spain.

During eleven years (1997 to 2007) in Spain we had a very high rate of urban growth that concerned to all type of cities: big, medium or small, either central or peripheral areas and coast line, especially the Mediterranean area. In these areas a high number of new houses, after the economic crash, remain empty. What is the future of empty, and sometimes, unfinished houses?

But the worst are the urban areas that keep vacant. Some new cities still have big areas waiting to be developed that concern to GLI. What to do, next future, with vacant urban areas, and with vacant Green Local Infrastructure? especially when these areas become a social problem and a public security problem.

So we need to study new answers for new problems.

The Spanish planning laws. "Lights and shadows" of laws in the beginning of XXI century.

More of urban problems in Spain, during the first year of XXI century, are the result of "slangy" planning laws enacted by the right-wing government in last years of XX century. These laws allowed to build in every place, in every land no specially protected by environmental laws, so cities arrived to territory with no order and with no urban structure.

So the gigantic growth become to all cities, small o big cities. But the problem arrived in the small and very small villages. Some of these cities become strategic because a new public infrastructure landed in that territory. For example, a very small city that tried to grow up when in the nearest territory an airport began to be constructed. But with the crisis this airport never received airplanes, so the new city crashed even before it was constructed.

These laws go against environment and benefited high urban developments that finally crashed also and let unfinished cities all around the country that are of very difficult solution.

And in the middle, we have the green infrastructures that, in some cases, never were carried on or are, also, unfinished. And what to say and do with green local infrastructures (GLI) finished and part of urban develop when the city is unfinished and never will be finished, are we allowed to destroyed them or changed into new uses, and in these case, in what new uses?

The "lights and shadows" we talk of these laws are in relationship with heritage of unfinished cities and unfinished green infrastructure. So, we need new laws. Laws that above everything protect the green infrastructure even with new temporal uses.

In this paper, we try to study the actions on the periphery of some big cities as Madrid and specially in the small cities in the second o extra-peripherical areas on Green Infrastructure, and we analyse the effects of law and its future changes.

In Madrid's case, we must remember that is the bigger Spanish city that around has small cities that tried to grow up also, but mostly crashed after 2009.

These are some of the questions we try to vouch with this paper.

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Sharing Places: Evaluating London's New Cycle-and Pedestrian-friendly Neighborhoods

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European cities, starting in the Netherlands in the 1970s, have paved the way for a widespread resistance to motorized vehicles in public places. While important older cities like Rome have been slow to join the car-free movement (despite their long history of dense streets and urban piazzas), London has recently launched a determined effort to imitate the Dutch model. While the most recent initiative, dubbed Mini-Hollands, is still in the early stages of experimentation, the network of Quietways and Cycle Superhighways which make up the Central London Grid began implementation in 2014 and seven Quietways are due to be operational by 2017. It is thus a crucial time to document the public reception of these projects and evaluate their impact.

The research project aims to document the effects of Transport for London's current initiatives to transition from private motorized traffic by improving urban cycling routes and safety.

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Integrated approach for innovative urban green infrastructure design thinking

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Green infrastructure projects approach and innovative design thinking is often limited or not informed across disciplines and more than often disregard the importance of precisely fitting / splicing the 'green' and the 'infrastructure. As a result, they are less successful.

This presentation will examine (real and perceived) challenges, benefits, and lessons learned associated with having multiple disciplines and community members come to the table to discover new ways nature and technology can work together. It will showcase

trans-disciplinary innovative holistic design thinking, prototyping, testing, and construction in green technology materials and methods, thoughtfully and intimately combining nature and technology based on optimization of plant growth and system productivity.

Creative and innovative trans-disciplinary thinking causes the ability to see new relationshipsin systems and networks that might not have been revealed using just one specific disciplines lens. Advancing an understanding of trans-disciplinary academic-professional benefits associated with studying combined integrated nature and technology systems can help facilitate a more successful discussion for improvement and maintenance of green technologies across disciplines.

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Green Infrastructure challenges in future urban planning

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Green Infrastructure has made rapid advances into European planning practice. The GREEN SURGE project (Green Infrastructure and Urban Biodiversity for Sustainable Urban Development and the Green Economy, FP7-ENV.2013.6.2-5-603567) has provided evidence to suggest that planning practice has still to catch up with recent developments in this field. Indeed, it is arguable that developments in green infrastructure are running ahead of the planning systems ability to flex and change. How then will Green Infrastructure fare in relation to future urban planning? The challenges investigated in the presentation are:

- How can beneficial interdisciplinary approaches be sustained in a resource limited governmental sector?
- How can preeminent approaches such as those related to urban nature be incorporated without diminishing their distinctive contributions?
- How might Green Infrastructure avoid being tarnished with neoliberal, gentrifying and post-truth epithets?

The discussion and conclusion focuses on how Green Infrastructure can be essential urban infrastructure that delivers benefits to all parts of society whilst being flexible to changing needs.

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Identification and presentation of the heritage potential of historic cultural landscapes in the Czech Republic

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Landscape represents a key part of our life and is a specific component of our cultural heritage. In its variety and individuality, landscape helps create national identity and is a source of historical knowledge, of artistic inspiration, and the carrier of environmental and economical values. Culturally and historically significant areas (harmonically preserved landscapes with visible traces of human activity, which are designated as historical cultural landscapes in the system of heritage preservation) require responsible and systematic care, which must be based on the identification of these areas and quality identification of their heritage values. This is the primary condition of their territorial definition, responsible regulation of their further development through presentation to various target groups. Such care should include areas that are already covered under heritage designation, but mainly areas with high heritage potential that need to be defined (including those that are not included under legal protection yet).

Protection of areas with historical values is the subject of several international conventions which the Czech Republic has joined as well. These are namely the Convention Concerning the Protection of the World Cultural and Natural Heritage (CCPWCNH), Convention for the Protection of the Architectural Heritage of Europe, and European Landscape Convention. The executive directive of the CCPWCNH, adopted in 1992 on the 16th meeting of the UNESCO World Heritage Committee in Santa Fe defined cultural landscapes as combined works of nature and man, which document the evolution of the human society and its settlements throughout the history, under the influence of physical limitations and/or opportunities determined by their natural environment and the influence of gradual social, economical, and cultural influences, internal and external.

In the Czech Republic, landscape protection is performed by various laws and resorts of administration. To protect historical cultural landscape the primary legislative tool is the Heritage Act, which covers the care of heritage reserves and heritage zones. Other legislative tools include the Act on Nature and Landscape Protection and the Building Act.

Improving the existing system of protecting and preserving the historical cultural landscape and the institute of the landscape heritage zones is the goal of a recent interdisciplinary national and cultural identity research project No DG16P02M034 titled "Identification and Presentation of the Heritage Potential of Historical Cultural Landscape in the Czech Republic" recognised by the Ministry of Culture of the Czech Republic for the period of 2016 – 2020. The effort is to build on the outcomes of previous research projects and to further develop the interdisciplinary collaboration in historical cultural landscape, which is performed between the Silva Tarouca Research Institute for Landscape and Ornamental Horticulture, National Heritage Institute, Czech University of Technology, and Mendel University.

The aim of the project is to identify, document and present findings on values of the historic cultural landscapes with a heritage potential; to elaborate existing scheme of protection based on monument conservation zones through identifying the typological base in order to recognize the potential of protecting previously unprotected parts of the historical cultural landscape; to raise awareness and protection of the values of historical cultural landscapes as an important part of national identity, cultural heritage and implementation of international conventions.

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Blue green infrastructures to reinforce cultural promotion of landscapes: a proposal for the Vesuvian coastal area

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Blue Green Infrastructures could have an important role in improving climate adaptation, decrease vulnerability to natural risks, and enhance ecological performances of landscapes. Many times these targets hardly emerge as priorities of urban actions due to the endemic lack of economic resources. Therefore, linking these targets to economic development goals could get urban policy makers actively involved in the creation of blue green infrastructures.

Our proposal consists in giving to blue green infrastructures a use value for communities and all the people using territories and urban areas for daily life or in special occasions, as cultural events.

The case study presented is the coastal area near the Vesuvius, in the metropolitan area of Naples. This area is plenty of archaeological resources, landscape values and natural assets, which have a scarce accessibility and never have been considered as an integrate and unitary system. Notwithstanding the high value of these cultural resources, tourism neglects this area. Moreover, during last decades the area has seen a rapid urbanization mainly based on illegal urban development, giving raise to pollution, natural resources decay, ecological fragmentation and erosion of agricultural soil.

In addition, a high seismic and volcanic risk affects the area due to the Vesuvius, forcing urban authorities to plan emergency paths in a high densely urbanized area in order to reduce the traffic flows on existing evacuation routes.

The idea of the paper is to join the regulative and regenerative function of blue green infrastructures with the enhancement of cultural resources of the area and with the risk management, designing a network of blue green infrastructures crossing the area and able to reconcile different needs.

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Evaluation of University Campuses in terms of Urban Green Area and Green Infrastructure; Black Sea Technical University, Kanuni Campus (Trabzon-Turkey) Example

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A significant indicator for the level of civilization and development of nations is the existence and quality of urban green areas. Thus, by providing for physical and cognitive needs of individuals, urban green area planning and sustainability contribute to the ecologic and economic improvement in improvement of environmental quality.

Green infrastructure is one of the innovative protection models for the conservation and sustainability of natural resources. In addition to its natural and functional benefits to the ecosystem, it provides a cultural link between open spaces and urban landscape. It is also very important in terms of positive effects on human health and contribution to biodiversity. An urban space, the university campus, in addition to being an area of education and instruction, is important in terms of urban identity as well. Karadeniz Technical University, established on May 20, 1955, is the first university in Turkey found outside Istanbul and Ankara provinces. Kanuni Campus of the university is located at a very central location in the city.

In this study; The level of green area qualification of the KTÜ Kanuni Campus and its contribution to the urban landscape has been researched and it has been aimed to determine the potential of green infrastructure and its contribution to ecosystem services. In the three main titles for revealing the current situation, identity cards were created in line with the specified criteria. These criteria were evaluated and analyzed for each study area. Thus, the potentials of the green area within the city of the campus have been identified and strategies for analyzing and increasing the current situation have been determined.

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Between tree lovers and tree haters - drivers of public perception regarding street trees and its implications on green infrastructure

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Street trees can play an important role in the urban green infrastructure. However, changes in the urban fabric often have perverse effects on the structure, diversity and performance of street trees. This research explores how changes in the urban fabric affect the performance and the public perception of street trees.

The study took place in the city of Porto, Portugal, and examined more than 800 trees located in coastal neighbourhood of Foz. Street tree planting in this area began in the 1930's, when the urban fabric was dominated by single family houses. In the second half of the 20th century, multi-story housing gradually substituted for single family detached houses. This marked the beginning of the conflict among street trees, buildings and residents, which has been increasing with the growth and ageing of trees.

The working methodology includes: 1) a characterization of each street; 2) a tree inventory and diagnosis; 3) a survey to evaluate public attitudes and perceptions on street trees. All the surveyed trees showed some signs of health problems related with severe pruning and overall limiting growth conditions. While more than 90% of the respondents assumed themselves as tree lovers, almost 30% felt that the trees were not well planted in the surveyed streets. Results of the survey on the public perception showed that some public perceived the problems identified by the experts during the inventory and characterization of streets and trees.

These results demanded for a character preserving intervention (streets with trees) while increasing diversity, improving aesthetic quality and mitigating existing and predictable conflicts, thus contributing for a better integration of the trees in the urban fabric.

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Nature protected areas as a core part of Green Infrastructure in Warsaw – threats and possibilities

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The study focuses on nature protected areas in Warsaw which constitute a core part of a green infrastructure of the city. Because of their high ecological, hydrological and climatic values as well as social benefits for city inhabitants, these areas positively influence people's comfort of life and contribute to a mitigation of climate changes. A current urbanization pressure and spatial policy regulations, however, result in a decrease of open areas in a city which very often leads to the isolation of nature protected areas and, as a consequence, affects negatively their functioning. GIS land cover analyses helped to identify the structure and spatial layout of these areas as well as their spatial relations to other open areas. The city of Warsaw prepared several documents so far that aim to preserve ecological and landscape values in the city scale, e.g. the Warsaw Natural System. However, because of a strong development pressure the areas indicated in these strategies as green areas are currently gradually built over. Due to lack of legal force, the strategies are not fully implemented. The study investigates the regulations of Local Development Plans which, in fact, play a decisive role in the spatial development of Warsaw. The authors assess how an extent and spatial layout of existing open areas, especially in the vicinity of nature protection areas, are going to change. The authors also aimed to determine the main human activities that threaten the functioning of areas that are under protection. A recognition of existing problems in the spatial policy regulations – in terms of nature protection in the city – is a key to the successful implementation of Green Infrastructure in Warsaw.

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Relationship between green areas and construction buildings in Tirana, Albania

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We can define Tirana as a new city in our country for his historical value and the architectural buildings that we have here. If you take a first look at this city it would seem like it has a high % of green around, but in fact compared to the level of population and the buildings per hight its very little.

The lack of green areas as it is known it causes enviromental issues. Environmental pollution is caused by heavy traffic, low quality fuels, old vehicles, new constructions which do not meet environmental standards, burning of waste in the city and in Sharra landfill, destroyed infrastructure all over the country and the disappearing green spaces.

It is by law that every new building that you are going to project including the plans, sections, analyses, facades etc, has his specific area dedicated for recreation and green surface, that concludes around 40% of the counstructing site.

Even if the law says so the staticits above all says that Tirana is today the capital with the most polluted air in Europe. The current situation of the environment, especially in the urban area is pathetic.

We need to think more about the future and to do so we need to focus more on the place that we live and act urgently to:

- Preserving existing spaces through calling a local referendum
- Building new parks in the extra urban zones, especially in the north and western part of Tirana.
- Greening some parks or public spaces which are currently covered in concrete.

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Establish the green infrastructure and ecosystem-based disaster risk reduction for the restoration efforts following the Kumamoto earthquake

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Japan is one of the most seismically active areas on Earth, accounting for about 20% of global quakes of magnitude 6.0 or greater. The magnitude-7.3 quake hit at a depth of 10km at 01:25 on Saturday 16 April 2016 (15:25 GMT on Friday) in Kumamoto Prefecture in Kyushu region, Japan, and a foreshock earthquake with a magnitude-6.2 at quake hit at a depth of 11km at 21:26 on 14 April in same area. This series of earthquakes was named The 2016 Kumamoto Earthquakes. We are currently exploring solutions to minimize the impacts of natural disasters and landscape changes by focusing on green infrastructure and ecosystem-based disaster risk reduction in Minamiaso Village in Aso District, Kumamoto Prefecture. It is important to understand the process of historical transition with regard to the occurrence of natural disasters in such areas. In this study, we describe the effects of the location and design of sacred places, such as shrines, with consideration of security against natural disasters, and the ecological and biocultural characteristics of the selected site. Shrine forests are protected and managed in near-natural conditions for purposes of religious worship, and many are located in ecologically rich areas. It was found that shrines tend to be dispersed in certain areas. 68% of shrines have been built on slopes. To investigate the geographical features and their relationship with ecological resources, a continuous green space was generated by forming a buffer between the spaces of forests that include shrines and the surrounding green space. Many shrine forests are located in areas considered safe from the effects of natural disasters, and placed under legislative protection by being designated as national or regional monuments of historical value.

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SESSION 10
GI in future urban planning

POSTER

Greenery structure in the huge housing estates areas in Poland before and after political system transformation. The city of Poznan as case study

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The huge housing estates are a permanent and distinctive element of the townscape in Poland and the other post-communist countries. Built in the second half of the twentieth century in response to the enormous housing shortage caused by Second World War damages and at the same time with its impetus and the scale superbly became part of trends of the socialist urban planning. These spectacular investments, built according to the contemporary ideology were a word of subordinating all aspects of life to the communist frenzy. Comprehensively planned, with full infrastructure they were an example of a model of a unit, which satisfied the needs of all of their inhabitants. In such units the green areas had to satisfy the needs of the rest and recreation, simultaneously creating the clear structure dividing housing units.

How, after the political transformation in 1989, do these units function now? What happened with the vision of housing estates wrapped in green areas, to which every resident is having access? The pace as well as the scale of social-economic changes which started after knocking the communism down caused the avalanche of problems which firmly hurt exactly such green areas as well as put the row of challenges which we are currently facing.

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Effects of urban transformation on ecosystem services in valleys ‘Zağnos valley example – Trabzon, Turkey’

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Concept of Urban Transformation is defined as a "Comprehensive Vision and Action" aimed at providing a permanent solution to the economic, physical, social and environmental conditions of a region that is in the process of resolving urban problems and undergoing a change. The need for transformation in cities is due to the distortions in urban areas, economic and social systems. As a result of the irregular construction and unplanned urbanization in the past, Turkey needs urban transformation projects in many places.

The relationship between ecosystem services and cities is complex and multifaceted. In urban areas, the land cover of un-urbanized areas includes different typologies. These areas are semi-natural, covered by significant vegetation within urban borders, and are generally part of urban green infrastructure and agricultural areas that offer ecosystem services and have different physical characteristics, social and ecological functions.

For a city, the valleys are very important both in terms of recreational use value and contribution to city health and quality of life. Valleys can also increase the potential of urban landscapes. Zağnos Valley is a transitional zone in the city center. It was declared by the Municipal Assembly in 2005 as the 'urban transformation area'. Urban transformation studies have been completed and the valley is now used as a recreational landscape area.

In this study, changes in pre- and post-urban transformation were determined by analyzing the present situation of Zağnos valley in terms of ecosystem services and green infrastructure possibilities. Thus, the contributions of the valleys, which are very important in the city of Trabzon, to the ecosystem services have been examined.

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Green road infrastructure in Cittaslow Towns – case study of Poland

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Transportation infrastructure is a significant component of these settlement structures, and planning its development is one of the major tasks of spatial planning both in urbanised areas and outside them. That is why it is important to the proper planning of green space in the small towns with particular importance, eg. in the Cittaslow towns.

The Cittaslow movement emphasizes the importance of public space, esthetic surroundings, infrastructure and green areas. Due to the proper employment of greenery, the streets in small towns may be safe and aesthetically pleasing. With the use of greenery it is possible to reduce, to a large extent, the adverse effects of vehicular traffic associated with the road traffic hazards, excessive exhaust fumes and noise emissions, or transport-related vibrations. Moreover, appropriate arrangements enable the application of greenery as natural components facilitating the traffic calming, and using it in order to create aesthetic and permanently calmed traffic zones. This is how safe public spaces are established, which are friendly towards local communities and providing them excellent conditions for the social neighbourly life (Jamrozik 2009, Jaszczak and Zukowska, 2012).

This paper deals with a concept of planning transport infrastructure based on the principle of establishing spheres and shared spaces. Examples of how roads and their environs can be planned in one of Polish Cittaslow Town (Biskupiec) are presented. The research consisted in collecting sources and interpreting information and documents. Other than monographic research, the author has made landscape and space analysis in city centre, has conducted pre-project study and has made a project for main square and traffic zones that was later implemented. Adding greenery to a traffic calming measure can improve it both aesthetically and functionally.

The issues raised in this paper are an attempt to find an answer to an important and by no means a rhetorical question: how to reach a compromise between eco-friendly actions undertaken to manage the landscape, including urban green areas, and the prerequisites that must be taken into consideration when planning transport infrastructure and improving road safety?

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Integration of green infrastructure in landscape plans in Turkey

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Today, concepts such as climate change, biodiversity and sustainability bring about significant changes in the shaping of living environments and in the content of planning and design tools that provide them. Traditional urban planning and design practices against existing and multi-component (ecological, social and spatial) issues such as sustainable urban development, future urban scenarios, multicultural life, existing legal and managerial mechanisms may be inadequate. Ecological urban planning is aimed at expanding the fields of activity of occupational disciplines such as ecological or sustainable urban design, green infrastructure, new urbanism, green urbanism, green architecture, as well as bringing effective and alternative solutions to the above-mentioned issues.

With the legislation regulated in Turkey in 2010, changes in authority have been made in the context of management at urban scale. Within the scope of these changes, the place of landscape planning in the planning hierarchy has not been defined, so environmental pollution, destruction of natural and cultural values, ecological problems, natural and cultural losses due to population pressure. The physical plans produced by this approach, which considers natural ecosystems as a separate phenomenon, are far from being able to produce solutions for day-to-day solutions and to solve long-term problems.

Within this scope, the borders of the Metropolitan Municipality of Samsun city were selected as the study area and the most important "landscape infrastructure" of the Kızılırmak Delta city located within the borders will be studied. Kızılırmak Delta; It has an area of 56,000 hectares, of which 12,000 hectares are in the wetland regime and 21,700 hectares are Ramsar Field. It is the only wetland on the Black Sea coast of our country that has its natural characteristics protected to a great extent by the existence of different living areas such as sea, rivers, lakes, reeds, swamps, meadows, pastures, forests, sand dunes and agricultural areas together with important biological diversity And entered the UNESCO Interim List of Natural Heritage. It was determined that all natural and cultural analyzes and analysis results were not found in the plan hierarchy in the central and local level within the scope of the study for delta which contains all these features and it was aimed to create a planning management proposal by examining the field in the context of green infrastructure.

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Treescape design - From forest ecosystem services to spatial forest configurations for an urbanized territory

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Flanders is one of the least forested areas in Europe and, because of the typical ‘dispersed urbanity’, only a pattern of many small and few larger fragments of open space – including forests – remains. There is an undeniable and urgent need for more trees and larger forest areas in a robust open space, in order to ensure the provision of necessary ecosystem services. In a metropolitan area, this forest assignment requires a design approach on a landscape scale and new spatial concepts based on the multiple use of space.

In this context, the PhD project ‘Treescape design’ (started October 2016), introduces the concept of forest configurations. The aim is to generate new spatial design concepts for forest expansion in relation to more urban land use in the fragmented spatial context of Flanders, based on the optimization of ecosystem services benefits for society and using ‘landscape research by design’ as methodology. Starting from a selection of forest ecosystem services, the relation between these services and spatial criteria is set in diagrams and transformed into spatial design principles for trees and forests. Then, new concepts for forest configurations are developed and applied in the design of a treescape for case study areas. Treescape refers to tree and forest vegetation systems as landscape architectural interventions on a larger scale. Potential forest configurations are: residential forest (dwellings with woodland gardens), business forest (wooded business park), agricultural forest (food forests).

At this moment all 'potentially to be afforested' open space units in the city region of Ghent are defined. By the time of the conference, it will be possible to present the first results of an evolutionary design process towards a treescape for this region.

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The green future of Naples' metropolitan area

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The future of regional and urban planning is oriented, slowly but surely, towards the integration between territorial and ecological planning. The aim to be pursued by future planning is sustainability, and this unfailingly requires a usage of the territory more careful towards the themes of landscape and ecology; this means to point out the limits of compatibility and usage which are necessary to grant environmental protection and the conservation of biodiversity. In Italy, to give environmental value to planning activities it is necessary to fill the gap that comes from the absolute shortage of environmental data in processes of territorial and urban planning, introducing a survey phase of the studied areas. In this respect, the planning of *green infrastructures* is aimed at planning actions thought to respond not only to recreational and landscape exigencies in urban and extra-urban areas, but mainly to increase cities' resilience towards the pollution given by the human factor on environmental matrix. This paper aims at realizing the fine-tuning of a totally sustainable settlement pattern for Naples and its metropolitan territory, based on the valorization of disused areas and hypothesizing restoration, recovery, reconstruction and reuse of urbanized areas activities.

To grant protection of biodiversity and natural areas, it is necessary to that the management of the metropolitan area is oriented towards the ecosystem management of urban and extra-urban green areas. The structural component and teh natural conformation of Naples metropolitan area's territory are a great environmental reservoir; as a trait d'union between the historical city, its northern suburbs and the municipalities that form the first north-western conurbation is the green infrastructure that extends from Campi Flegrei to Capodimonte.

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“Trees of Public Interest” - a management tool for urban forest monitoring

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This study focus on remarkable urban trees, which are an indivisible part of the urban forest and constitute a heritage of very high ecological, cultural and historical value, instrumental to the ecological and social dynamics within the city.

This work took place in Porto, Northern of Portugal, a medium size city (near 240 000 hab.) that owns an important collection of historic squares and gardens filled with ancient trees, of monumental sizes and wide range of species, both native and ornamental exotic.

Since 1938, Portuguese legislation has a specific classification for remarkable trees, classifying them as “Trees of Public Interest”, aiming at its preservation and protection. This classification is granted by the Institute of Nature and Forest Conservation (ICNF) and applied “to forest, woods or groves, arboretums, alleys and gardens of botanical, historic, scenic or artistic interest, as well as to isolated specimens which by their representativeness, rarity, size, age, history, cultural significance or scenic backdrop, might be considered of relevant public interest and recommend its careful conservation.”

The goals were to identify and map (ArcGIS 10.2.1) all trees or groups of trees liable to classification and prepare the applications. The methodology involved an extensive literature review and field work. For all trees dendrometric and physiological parameters were measured and assessed their health.

The final group of “Trees of Public Interest”, integrate a roadmap that explains to Porto inhabitants and visitors their importance for the city's identity and environmental performance. Recognizing the challenges of the management of these trees, at the expenses of the municipality, a set of strategic guidelines were also compiled.

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Green and compact? Green infrastructures and land-use dynamics of EU cities in the light of future urban planning

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The availability and spatial distribution of green infrastructures in cities is driven by complex land-use dynamics. The goal of increasing the amount and the quality of green is in clear competition with the growing per-capita demand of urban land. Moreover, other sustainable planning paradigms, such as the compact city, high density, in-fill development, and there-use of brownfields, may conflict with the enhancement of green infrastructures.

Our research aims to investigate how different development dynamics of European cities (>100.000 inhabitants) affect the availability and spatial distribution of urban green infrastructures. We analyzed a large sample of 180 EU cities, comparing high-resolution land use maps for the years 2006 and 2012. Quantitative indicators of density and land-use changes as proxies of different development dynamics are coupled with qualitative indicators that describe their spatial outcomes on the ground: a set of landscape metrics is used to assess both compactness of the city and quality of green infrastructures, in particular their connectivity and proximity.

Our results show that in the majority of the analyzed cities, the total area of green spaces declined. In the cases where the amount of per-capita green increased, this can be interpreted as a consequence of shrinkage rather than the result of a successful implementation of greening strategies. At the same time, in many cities, especially growing, small and medium-sized cities, brownfields and other lands with no current use increased. Changes between the two reference years are discussed and compared with possible future scenarios (e.g., the conversion of brownfields into new green spaces), to provide insights that can guide planning strategies for the future of European cities.

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Access to the green infraestructure: environmental justice and green gentrification

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Green infrastructure provide numerous ecosystem services that affect positively the people's lives. However, is recognized that exist inequality in the distribution of the urban green infrastructure that results in environmental justice issues. The well-off classes have more access to the qualified green urban spaces than the minorities, elderly or disabled people. In an attempt to control this inequality, several requalification projects in the poor neighbourhoods have been promoted. However, when the projects are not integrated with the urban green space framework it can results in an urban green space paradox of gentrification (Wolch, Byrneb, & Newell, 2014). These phenomenon is arising in consequence of landscape improvement that increase the cost of housing and deprived residents may not be able to support the cost of life. This results in the exclusion or displacement of the poor residents, who should benefit from the ecosystem services provided by the new green space. In turn, the residents will return to live in a degraded neighbourhood, with low access to green infrastructure. The purpose of this paper is to analyse case studies of soviet-era housing blocks in Estonia and propose solutions to avoid the green gentrification phenomenon controlling the inequality between the green infrastructure in the city heart and the green infrastructure in those poor neighbourhoods.

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Nature-based solutions for urban challenges

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Cities face major challenges caused by an increased urbanization and climate change. Extreme weather events, may induce major economic consequences for society, enterprises and individual citizens. Additionally, the cities need to handle increasing social and economic inequalities. Traditionally, technical solutions, such as storm water management dominate the solutions for urban challenges, but nature also offers solutions and in recent years' the concept nature-based solutions (NBS) have been emphasized as alternative green options for managing sustainable cities.

The five-year long project will (1) examine how NBS are spatially distributed in Swedish cities and how this influence which functions (ecosystem services) they contribute with to meet urban challenges, (2) examine if NBS can be optimally distributed in urban spaces in relation to biophysical and socio-economic factors, and how NBS counteract or contribute to social equality, and (3) identify barriers and drivers in the implementation of NBS in the municipal administration to support a successful use of NBS in cities. In a final step (4), the project will synthesize the knowledge base and develop future scenarios for how the spatial distribution of NBS can be optimized for efficient climate adaptations and simultaneously increase human well-being and social equality. The project will take a transdisciplinary approach, utilizing a broad expertise of various research disciplines and a reference group of stakeholders from Swedish municipal administrations, national and regional authorities and other organizations.

Tight collaboration with the stakeholder group will ensure that the project get continuous feedback on research questions, scenarios, processes and models and that the results get a "real-world" testing.

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The residential areas as a potential to forming city green infrastructure- Warsaw example

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The aim of this study is to determine needs and possibilities of transformation of the existing residential areas in terms of their importance to be a part of the green infrastructure of the city. The work focuses on efficiency of nature processes, greenery standard impacting the recreational areas and a quality of life of city residents. The work raises also the possibility of development ofhousing estates in order to adapt to the anticipated effects of climate changes, in particular: heate waves, torrential rains, strong winds and to improve the climate ofthe whole city. The subject ofthe research are various types ofWarsaw residential areas: the estates built in 70-90s, housing developments, modem sustainable housing estates. The authors define green elements of development that build green infrastructurein a locai scale. The conducted analyses present examples of good practices that shape sustainable residential areas, which create favorable conditions for life and take into account the problems of modem cities of XXI century.

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Effect of green infrastructure on determination of rural-to-urban transects

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The evaluation of cities caused by urban sprawl have had a long tradition. One of the analysis method of urban sprawl is rural-to-urban transects. This American approach based on the concept of ecological transect, which are used to describe changes in habitat over some gradient. There is a lot of investigations which have applied rural-to-urban transects, but the research focus on urban and socio-economic issues, rarely on environmental aspects. The main aim of present study was to evaluate the effect of green infrastructure on determination of rural-to-urban transects in Poznań city (Poland). Poznań city is one of the largest city in Poland. The city has a long development history and a specific spatial and functional structure – the wedge-ring system of green area which bases on river valleys. In the study the eight rural-to-urban transects were determined: four basic located in the built-up areas and four auxiliary located in green areas. The transects extend from urban core to the boundaries of the city. To evaluate the effect of green infrastructure on determination of rural-to-urban transects, the landscape metrics were calculated using the FRAGSTATS 4.2 software.

The obtained results showed that method of rural-to-urban transects is not adequate for certain cities, especially for these with difficult spatial and functional structure. In the Poznań city only urban core and center zone were not disturbed. The determination of another transect zones was difficult, because the green areas were mixed with built-up areas. This situation refers to many European cities, hence the American method of rural-to-urban transects should be modified with taking into consideration various kinds of green infrastructure, such as parks, gardens or cemeteries.

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Green mobility infrastructures in urban landscape. a systemic approach for roundabouts' gardens in Imola, Emilia Romagna Region – Italy

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The paper presents our point of view and a multi-criteria method for unitary projects related to open spaces along urban road networks, considering them as integral part of broader landscape systems and therefore as an unmissable opportunity for the construction of green infrastructures. The extension of roads networks and the evolution of their typologies have gradually gone creating a remarkable repertoire of new types of open spaces which, despite their small individual extension, on the whole can no longer be neglected. In fact, an innovative urban planning can offer the possibility of transforming these residual spaces into a distinctive feature of the city, into a green infrastructure with a landscape value. Within this framework, we present a pilot case on green spaces inside and adjacent to urban roundabouts of the City of Imola (Bologna), in the Emilia Romagna Region (Italy). They have been conceived as interface elements between infrastructure and cityscapes, and in particular as gardens, in order to improve the cultural of the sites and a responsible use of environmental resources, evaluating also the need for sustainable construction and management solutions. By means of a systemic and cross-scale approach, our proposal about roundabouts landscaping is based on a combination of multiple design issues (scenic values, landscape ecology, socio-economic sustainability) and specific characters of the context, with the aim of fulfilling aesthetic and functional requirements at the landscape level. The study defines spatial composition criteria, vegetation abacus and maintenance plans, articulated according to the various systems we identified and the following greening categories: Wild Flowers areas, Urban Groves, Rain Gardens, Dry Gardens.

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Inspiring sustainability techniques embedment in industrial parks

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A resilient city is designed with consideration on social wellbeing, on natural capital restoration creating the smallest possible ecological footprint and on climate change adaptation and mitigation. The purpose of this paper is to present a feasibility study that proposes a formal and aesthetic solution with respect to the spirit of place, with landscape integration of the infrastructures and embedment of sustainability techniques in a conceptual level Masterplan of a new industrial park in the Portuguese city of Tavira. It proposes a multi-modal transportation system solution, it promotes green infrastructure interconnected with the hinterland green areas and mixed-use multifunctional landscapes, it endorse a

decrease in impervious surfaces and enhance efforts to reduce energy use adopting renewable energy lighting solutions and green-roofs/walls using native vegetation and urban allotments to decrease heat island effect. It recommends compactness of the urbanized areas to save soil and facilitate the integration in the environment. In this study it is demonstrated that ustainable landscape design in industrial setting may assure a quality and prestige living environment. The authors acknowledge the financial support given by EU under Project INSPIRATION, H2020-SC5-2014-642372: Integrated Spatial PlannIng, land use and soil management Research Action and project WARECAMO: Establishing new scientific and research networking in the field of water reservoir storage capacity monitoring addressing the issue of climate change.

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An overview on the presence of green infrastructures in urban policies and strategies from Romania

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Urban green infrastructures represent a concept increasingly used both by scientist and public administration due to their ecological, economic and social benefits they provide for the sustainable development of settlements. In Romania, the development of integrative urban infrastructures is facing challenges represented by the planning regulation, strategy of public administrations and perception of different actors involved in the processes.

Our study starts from the development policies and strategies of Romanian cities for the past 5 years, analyzed using a standard data format filled in by 4 encoders, which extracted information about the presence/absence of green infrastructures, specific objectives, indicators for monitoring. The information was analyzed using statistical indicators that allowed us to extract the main principles adopted by local authorities, group cities according to their approach of green infrastructures and present knowledge gaps which should be covered for an integrated development of urban infrastructures at city level.

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From fragmentation to integration: Landscape planning as linker of Infrastructures

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Over the last centuries, the urban planning process has led to forming numerous "vacant" spaces, which can be articulated or not, urban and / or peri-urban. Such spaces are mostly at the "perceptual and physical" margin, "pending" places that downtime the "turning point". According to the green infrastructure concept, negative effects of such planning approach can be adjusted by adapting built elements on eco-environmental context.

What would be the purpose of a pioneer planning? Should be constructing "in" the context or constructing "the" context? The proposed hypothesis foresees a reversal of tendency: composing new landscapes which can contain new infrastructures. Posterior adaptation of Infrastructures will be overturned by adequate landscapes as a prior design. These infrastructures are the product of a combination of articulated and complex landscapes, where the recognition of the empty complexity becomes the disciplinary principles for all built elements. The base criterion for the realization of new green infrastructure, is the composition of contextual mosaics. Such context is highly sustainable for the new infrastructure complex.

According to the analytical parameters of information and spatial relationships (geoprocessing), will be identified four criteria for the spatial organization of context as infrastructure base: territorial dimension, distance from existing infrastructure, density of construction and environmental quality.

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Green Infrastructure Approach for Touristic Regions under Climate Change: challenges and strategies of resilience enhancement

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The low differentiation of touristic products allied to environmental degradation derived from climate change put the sun & beach touristic destinations, like Algarve Region, southern of Portugal, in a fragile situation to future challenges.

Actually, the sun & beach tourism in this Mediterranean climate region is already showing signs of decline, which, linked to future climate change, sea level rise and the potential beach area reduction, may constrain the resilience of a region that strongly depends on this type of tourism.

In this context, this article discusses an innovative strategy of regional resilience enhancement which could involve, on one hand, the containment of trend coastal urban expansion and, on the other, the consolidation of other sustainable tourism products, such as nature-based tourism and cultural-landscape touring, sustained on green infrastructure as a cultural adaptation strategy, diversifying in a competitive way the regional development basis, diminishing regional asymmetries between coastal and interior areas, and outlining a green infrastructure approach as a tool to inform the current practices in spatial planning.

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Attendances and Accessibility of Urban Forests in Lithuania

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Under prognosis according urban dwellers number urbanization level in Lithuania in 2020 will reach 75 %. However, since joining EU (2004) total number of Lithuanian population decreased by 15 %. Nowadays urban development trends shows, that it is becoming common in Lithuania "the urbanization without growth of urban dwellers". Urban sprawl into periurban areas without the growth of urban dwellers number causes irrational use of energy, land, nature resources, increase the expenses of public infrastructure. By incomprehensive urban planning it could be problematic to ensure forest ecosystem services for urban societies later.

Research on forest accessibility and citizens' needs is ongoing worldwide. The aim of this study was to assess urban dwellers preferences to urban forests in Lithuania case, particularly – their accessibly for daily use. Questionnaires (carried out in 2015-2016, more than 900 respondents) results were analyzed on questions of urban dwellers attitude on forests areas accessibility and their use. Multivariate analysis methods were applied to analyze the reasons influencing attendances of urban forests in respect to distance to urban dwellers. This research helps in promoting urban forest services in low control urban sprawl cases and compares the similar research results done in other countries.

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SESSION 11
Assessing and mapping Ecosystem Services generated by urban GI

ORAL

Keynote Speaker
Assessing and mapping ecosystem services generated by urban gi

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Globally, more people live in urban areas than in rural areas, with 54% of the world's population living in cities in 2014. As the world continues to urbanise, sustainable development challenges will be increasingly concentrated in cities. Urban ecosystem services, defined as the benefits provided to urban residents by nature in cities, are thus an essential point for future urban policies and planning.

Urban green infrastructure provides a number of urban ecosystem services relevant for a higher quality of life of city residents. Green infrastructure elements such as parks, street trees, urban gardens, green roofs or facades form increasingly part of urban planning strategies. The integration of green infrastructure in urban policies and planning strategies requires tools to assess and monitor progress of policy and strategy objectives and to support local urban planning. This presentation illustrates how selected urban ecosystem services and related green infrastructure can be presented on thematic maps particularly relevant for cities. Concrete examples are based on Urban Atlas (EAA) and local data using city threshold values applied in a GIS analysis approach. In particular, regulating and cultural ecosystem services using climate regulation and recreation as example ecosystem services are presented. Other maps illustrate green space availability values to highlight if particular parts of a city may less benefit from potential ecosystem service provisioning making this an aspect for an environmental justice discussion.

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An impact evaluation framework to support the planning and evaluation of nature-based solutions projects: Insights from the EKLIPSE Expert Working Group

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The European Commission requested the EKLIPSE project to help build up an evidence and knowledge base on the benefits and challenges of applying nature-based solutions (NBS) in urban areas. In response to the request, an EKLIPSE Expert Working Group (EWG) developed an impact evaluation framework with a list of criteria for assessing the performance of NBS in dealing with challenges related to climate resilience in urban areas, as well as an application guide for measuring how NBS projects fare against the identified indicators in delivering co-benefits. This presentation will provide an overview of the theoretical framework used for guiding the assessment of NBS impacts within and across 10 climate resilience challenge areas, a description of the quick scoping review procedure used to identify and synthesise key impacts, indicators and methods for each challenge and a synthesis of key findings and future research directions. Over 1,700 publications were considered as part of the review process. It was found that NBS can have environmental, social and economic benefits and/or costs both within and across climate resilience challenge areas. In some instances, benefits in one challenge area can lead to costs or neutral effects in other areas. Previous work found similar trends only with respect to the assessment of ecosystem service values, synergies and trade-offs, or in relation to specific climate change interventions. Future research would benefit from: 1) the systematic consideration of NBS co-benefits and costs within and across challenge areas, and geographic and temporal scales; 2) public participation and governance processes for weaving multiple forms and systems of knowledge into NBS design, delivery and implementation; and 3) further consideration of how existing or new urban planning regimes could interact with the science of NBS assessment.

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Linking supply and demand factors of urban green infrastructure

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Urban green infrastructure provides a number of cultural ecosystem services that are greatly appreciated by the public. In order to benefit from these services, actual contact with the respective ecosystem is often required. Furthermore, the type of services offered depend on the physical characteristics of the ecosystem. As part of our work in the COST Action GreenInUrbs we devised a model with demand or social factors on the one hand (user needs, preferences, values, etc.) and spatially explicit supply or physical factors such as amount of green space, (bio)diversity and recreational infrastructure on the other. Demand and supply factors are linked together to determine dependent variables such as levels of use, activities or health and well-being benefits. Based on this model, we conducted a review of European publications. The aim was to provide an overview of this highly interdisciplinary research, to describe how these linkages are being made and to identify which factors significantly influence the dependent variables. Results show that combining on-site questionnaires with visual recording of elements or off-site questionnaires with GIS data were commonly used methods. Links between social and physical data were usually established by using statistical tools or by overlaying different thematic maps. However, the significant effects in the end were relatively few, not consistent and largely dependent on the context. We conclude that an improvement and harmonization of methodologies, cross-country studies and an expansion of this line of research to a wider range of services and more user groups could help clarify relationships and increase applicability for urban management and planning.

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Breathing in the Mediterranean Parks: An initiative to assess GI ecosystem disservices in Mediterranean cities

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Allergic reactions caused by pollen emissions from urban vegetation are one of the main ecosystem disservices of green infrastructure (GI), with an impact on 30% of the population. According to the World Health Organization, this figure will increase in the coming years as a result of deterioration of urban air quality. In the Mediterranean region, the increase will be higher due to the effects of climate change and population growth. This paper presents a new index to estimate the potential allergenicity of urban parks, located in cities of Portugal, Spain, Morocco and Italy. The index allows the characterization of tree species based on their allergenic behaviour, highlighting among those with a maximum value some of the most representative species of the Mediterranean climate, such as those from Oleaceae, Cupressaceae and Fagaceae families. Other taxa that have been added to planting palettes like Moraceae, *Araucaria, Casuarina, Ginkgo* or *Eucalyptus*, also show a high allergenic value. The climatic diversity of the Mediterranean is also expressed in the species richness, estimated at about 200 taxa, with representatives from a wide range of species of different hardiness zones. The scale of indices obtained has been very diverse, from close to 0 (nill allergenicity) to values above 0,30 (threshold of allergenicity), resulting from the combination of both biological and biometrics parameters, but also depend on factors such as density of trees or surface covered by grass in each park. From the results, nature-based solutions that minimize the impact of pollen emissions on public health can be planned, such as the promotion of tree´s capacity to mitigate air pollution, the planting of species with different pollination strategies, the increasing of elements of blue infrastructure and the sustainable management of species with high water requirements.

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Multiple approaches for assessing tree canopy cover in Dublin City Centre, Ireland

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In recent times, there has been a marked increase in research on the biophysical, social and economic benefits of green infrastructure, particularly in urban environments and cities. The scale, size and duration of such studies vary considerably, however, a common starting point is mapping the extent and character of the existing green infrastructure, including parks, gardens and trees. Tree canopy cover is especially important due to a range of services that they provide to society. To acquire data on tree canopies and subsequently derive relevant information on their ecosystem benefits and services, technologies such as Geographic Information System (GIS) and remote sensing (RS) are required to create spatial databases for querying and analyses. In this paper, several GIS and RS methodologies (ArcGIS, SAGA, ILWIS, PCI Geometica, Erdas Imagine, ENVI and eCognition) are used to demonstrate the different approaches to extracting tree canopy cover in Dublin city centre. The results using each method differ in accuracies; however, the decision on which method is 'best' depends on various factors such as image resolution, availability and access of the relevant RS data, experienced personal and the necessary software. These issues are discussed along with the results from the various classifications and feature extraction approaches. The results of this study can provide a valuable guide to other researchers undertaking tree canopy assessments at a variety of spatial scales.

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Analyzing urban regulating services from a spatial planning perspective

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Regulating ecosystem services are linked to some of the most pressing urban challenges, from climate change adaptation to health. The integration of their mapping and assessment in urban planning is fundamental to achieving the associated policy goals, and to effectively implementing nature-based solutions. However, such integration is made difficult by a limited flow of knowledge from science to practice.

With the aim of providing planners with the most relevant information for integrating regulating services in urban plans, we studied seven services, focusing primarily on the analysis of the spatial interactions between service providing units (SPU) and service benefitting areas (SBA). The selected regulating services are micro-climate regulation, air purification, noise reduction, run-off mitigation and flood protection, waste treatment, moderation of extremes events, carbon sequestration. We distilled information from the scientific literature and systematized it into a framework that:

- Explains which spatial properties of SPU determine the ecosystem service potential, and clarifies the presence of thresholds and non-linearities;
- Investigates the spatial relations between SPU and SBA in terms of typology and scale;
- Describes the interactions between SPU and SBA and the environmental conditions of the context, including their variability in time and space.

Finally, we discuss how the framework can assist planners in understanding the spatial properties and dynamics that affect the distribution of regulating ecosystem services in cities, and designing nature-based solutions targeted at their enhancement.

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A stepwise method for assessing and valuing ecosystem services from urban greenery

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Despite increased awareness that greenery provides a range of important benefits to city residents, the fast urban exploitation increases the pressure to transform urban green spaces. To provide a tool on how to evaluate the services provided by greenery in relation to this and other pressures, the concept of ecosystem services (ES) is as an important tool. In response to this we have developed an empirically founded framework for integrated assessments of ES benefits and values of urban greenery. It is based on the cascade model (TEEB, 2010, Potschin & Haines-Young, 2011). The empirical data was collected from study areas in Gothenburg, Sweden. The model includes regulating and cultural ES:s from different urban ecosystems taking into account that a specific component (e.g. tree) can contribute to multiple ES:s in one or more ways. Ecosystems are valued by integrating contributions of the components and perceived values of the specific ES. The model has been presented in Andersson-Sköld et al. (subm.). The nearest months we will develop into a guide in cooperation with civil servants and representatives from various authorities. Here we will present the framework based on Andersson-Sköld et al (submitted) and our thoughts about the guide under development.

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Cultural ecosystem services provided by brownfield landscapes in the urban green infrastructure: case study Ruhr Metropolis, Germany

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Brownfield sites of Emscher Landscape Park represent integral components of metropolitan urban landscapes in Ruhr Metropolis, Germany. They are important industrial heritage sites and have become unique landmarks of the North Rhine-Westphalia Region. These cultural landscapes have always been productive and have gone through several transitional stages, such as production through agriculture and forestry some centuries ago or mining industries during the past two centuries. Due to successive closure of mines in this region over the last few decades, further transitions to 'new working landscapes' took place in various ways.

Numerous mines have been regenerated and transformed into urban forests and urban green infrastructures providing a wide range of ecosystem services, including social interaction and integration, leisure and recreation, education, heritage preservation, biocultural and aesthetical diversity, cultural industries, job creation and others.

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Mapping and assessing ecosystem services delivery by urban forests: providing the basis for action in urban planning and design

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Recent research has contributed to a great extent with methods to identify, quantify and value multiple urban ecosystem services (UES) delivered by green spaces and revealed that their provision can be highly heterogeneous within cities. This has allowed to acknowledge hot and cold spots of UES delivery across the urban fabric, frequently reflecting socioecological inequity in terms of access to the benefits supplied by nature. Urban planning can provide the means to deal with such socioecological inequity, through proper allocation of investment and resources toward cold hotspots of UES provision. However, the insights provided by UES mapping and assessment are often too general to convey orientation on how to tackle specific problems. As such, this knowledge remains poorly perceived and implemented in urban issues.

This presentation is intended to show how mapping and assessing UES can deliver specific, detailed thematic and spatial information useful for urban planning, management and design. Examples of research will highlight how structural variables of the urban forest such as tree size, density and species assemblage are affected by different types of green areas, management options and individual preferences, as well as socioeconomic patterns. These structural variables affect in turn UES supply, and provide tangible features that can be addressed by stakeholders to promote greater urban resilience and equity. On the other hand, appropriate UES mapping and assessment can contribute to draw attention to the fact that urban green areas are not all the same, and that quality of design and management can severely influence UES provision.

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Ecosystem disservices – when people turn against the trees

Johan Östberg

We all know that urban trees contribute with a vast amount of ecosystem services, but to fully understand and be able to argue for these benefits we also need to focus on the ecosystem disservices and the problem that urban trees can cause. This presentation will therefor focus on the ecosystem services, and peoples concern with trees. The presentation is based on a research project where all complaints concerning urban trees was recorded from tree municipalizes for one full year. This large data amount of data gives valuable information when trying to not only understand the ecosystem disservices, but also the perceived disservices that urban dwellers complain about.

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Assessing multifunctionality of urban green infrastructure for local planning decisions

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The principle of multifunctionality is a core element of green infrastructure planning. It is similar but not identical to the notion that green infrastructure is supposed to provide multiple ecosystem services. Multifunctionality considers interlinkages between functions and services in order to promote synergies and avoid trade-offs. In comparison, ecosystem service assessments tend to focus on mapping and assessing services separately and assess interrelations in a coarse resolution for large areas or land use changes. While a city's green infrastructure in total provides a wide variety of functions and services, increasing multifunctionality within one area requires a detailed study of functions and services and informed decisions on measures that promote optimal combinations, e.g. of cultural and regulatory services and functions for biodiversity.

An approach to assess multifunctionality of green infrastructure corridors and patches will be presented based on a case study in the City of Malmö, Sweden. The functions and services of green infrastructure elements, such as for biodiversity, recreation or stormwater management and their interrelations were assessed and priorities for actions were identified in cooperation with local stakeholders. The results for the site-level were used to discuss planning strategies for increasing multifunctionality in the whole city with local stakeholders. In the presentation the suitability of the assessment approach and the transferability of the developed strategies to other cities will be discussed.

The study is an outcome of the GREEN SURGE project, a collaborative research project funded by the European Union (FP7-ENV.2013.6.2-5-603567).

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Assessing Ecosystem Services of Bornova's Green Infrastructure

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Urban green infrastructure provides wide variety of ecological, social and economic benefits to urban dwellers. Understanding the dynamics of urban ecosystem services is essential for planning and managing practice of urban green infrastructure.

This paper aims to calculating and mapping regulating ecosystem services generated by Bornova's green infrastructure. Bornova is a highly urbanized district of the city of Izmir, Turkey. Almost 65% of the district is covered by open and green spaces that include parks, private gardens, playing fields, woodlands, shrublands, agricultural lands, olive plantations, streams, canals etc. In this research each components of green infrastructure will be analyzed to calculate carbon storage, air purification and run off retention ecosystem services by using I-tree model.

Findings will be discussed on the basis of guiding spatial planning practices for the provision of sustainable ecosystem services. Additionally some practical solutions will be offered to improvement of the regulating ecosystem services in order to make Bornova more resilient.

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Spatial decisions on ecosystem services

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City planners need tools and guidance to develop strategies for urban development using the natural capital approach. Businesses need to assess implications of development design options for ecosystem services and some standards require them to demonstrate net gain outcomes. In the UK, the Natural Capital Protocol tool provides a framework for assessing impacts on ecosystem services, but implementation is challenged by variable data quality and lack of tailored models to predict outcomes.

A team of UK collaborators from the private, research and non-government sectors has developed a new approach working with the construction industry and local authorities in London, Edinburgh, Brighton and Liverpool. A new green infrastructure typology, proposed as a standard, allows local data to be translated into a suitable format for ecosystem service modelling. The approach then examines eight cultural and regulatory ecosystem services at the city wide, district or development site scales so that users can explore the effects of development and greenspace options.

For each of the eight services the best available models were selected from the literature. Some are developments of existing open access tools while others use innovative solutions, such as the use of viewshed analysis to quantify the value of greenspace perspectives from inside offices and hospitals.

In line with the Natural Capital Protocol tool, outputs are presented in quantitative values wherever possible, and monetary value where appropriate. Users can explore spatial design options with the benefit of best available models and data. Adoption of the approach should contribute to EU and global targets for net gain in biodiversity and natural capital and the transformation towards sustainable, liveable cities.

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Towards an integrative approach to evaluate the environmental ecosystem services and disservices provided by urban forests

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To quantify the role of urban forests (UF) in the provision of environmental ecosystem services (EnvES) and disservices, well defined, reliable, quantifiable and stable indicators are needed. We classify UF EnvESs into three main categories: (i) regulation of air and climate, and provisioning of (ii) habitat quality and (iii) goods and services. Each category is divided into EnvES types, i.e.: (i) amelioration of air quality; amelioration of microclimate; removal of CO_2; (ii) provision of habitat for biodiversity; support for resilient urban ecosystems; provision of genetic diversity; and (iii) provision of energy and nutrients; restoration of soil and water; provision of infrastructure resilience. Each EnvES provides one or more benefits. For each of the 12 benefits, we propose indicators to be used when analyzing the impacts on UF EnvESs. Around half of these are relevant to more than one single benefit, which highlights the complex interrelationships among different UF EnvESs. The indicators of wider applicability are tree and stand characteristics, followed by leaf physical traits and tree species composition. Based on expert knowledge, we conclude that climate change and UF management have a high potential impact on those indicators. Management is an important tool to maximize EnvESs. Overall, the potential effect of climate change on the regulation of air and climate and on the provisioning of goods and other services EnvESs is estimated to be high. Major uncertainties exist about direction and magnitude of climate change effects on the biodiversity EnvESs. This knowledge is needed for UF EnvES optimization now and in the future. Also disservices of urban trees are critically discussed, as well as how they can be affected by climate change.

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The underestimated value of Mexican street trees

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Mexico City is facing a gradual loss and fragmentation of its green areas due to poor urban planning and development. Despite better current development plans, green areas are still rarely considered and rapidly destroyed. Street trees are often even less considered and subjected to constant removal and poor management. Partly this can be explained by limited awareness about their important role in pollution reduction, climate change adaptation and public health promotion.

This study looks at the status and benefits of street trees in Mexico City, focusing on Coyoacan, one of the greenest districts in Mexico City. The 2016 study carried out an assessment of urban forest by using i-Tree Eco, using a sample of 12 of the district's 95 neighborhoods. Moreover, an on-site resident survey was carried out to identify people's preferences, perceptions and 'tree awareness'.

First results show that trees in neighborhoods with higher levels of marginalization perform more poorly than those in low marginalization areas. The latter typically also have more street trees. Overall, the district has low biodiversity and a high percentage of diseased trees. In general, local residents agree that trees provide more services than disservices. Most people preferred having trees in front of their houses and in nearby green areas. People living in areas with scarce trees seemed to care less for them than people who live surrounded by trees.

Increasing the tree canopy cover in Coyoacan will not only increase carbon sequestration and pollutant removal; it will also improve the quality of life and aesthetics of poor neighborhoods. A long-term management program and stronger legislation need to be developed based on the current status of the urban forest and the needs and preferences of locals.

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Measuring composite ecosystem services potential at the neighbourhood scale

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Despite the increasing research considering urban ecosystem services, developing methods for assessing ecosystem services remains a challenge. There is lack both of a composite indicator that can summarise complex information into a single value and of neighbourhood scale land cover models which could be used in local contexts. Addressing these two research gaps could facilitate conversations between ecologists, designers and planners. The ecosystem services provided by different urban land covers at a local level were assessed in order to (a) develop a composite index of potential ecosystem services; and (b) validate the composite index's application at the neighbourhood scale. The composite index integrated sixty indicators under four heading: habitat diversity, habitat structure, leaf shape diversity, and engagement opportunities. Validation took place across twenty four sites in Manchester, UK, covering seven typical urban land uses in inner city areas: education, dwellings, amenity, vacant, offices, shops, and transport. At each site the percent of different land covers, the number of different leaf shapes, and the presence or absence of habitat and of public engagement indicators, were recorded during site visits. Five sites had high, and seven had moderate, ecosystem services potential. Amenity land had a lower ecosystem service potential than the education and dwellings land uses. The quality of maintenance, number of engagement opportunities, and variety of habitat types were major determinants of ecosystem services potential. The composite indicator presented here could facilitate effective and rapid assessment of ecosystem services potential at local scales.

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Using species traits as ecological indicators to quantify ecosystem services in urban green spaces

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With more than 2 billion additional people arriving in cities globally, the 21st century will significantly challenge the safeguard of urban environmental assets. Green Infrastructures (GI), "an interconnected network of green spaces", are becoming increasingly important as a strategic approach to preserve ecosystem values and functions and to provide benefits to human population (ecosystem services, ES). For example, supporting and regulating services preserve and enhance biodiversity, provide fresh air, reduce noise, and mitigate the warming climate effects. These services that GI provide help cities face enormous challenges such as air pollution, climate change and natural resource depletion. Understanding how urban ecosystems work, how they change, and what limits their performance, is crucial. The lack of empirical data linking biodiversity and ES in a quantitative way in urban GI prevents the operationalization of the concepts of ES and natural capital. Thus, we aim to link species functional traits to ecosystem functioning and finally to ES quantification in urban GI under different contexts. For that we will measure species traits from several groups of organisms typically used as ecological indicators to quantify supporting and regulating ES in urban GI in several cities of the Mediterranean. Maps and data showing the quantification of the ES provided by GI related to air purification, climate regulation, carbon sequestration, habitat quality, will be shown and discussed in terms of planning and trade-offs between ES.

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Assessing the ecological status of urban forests in Parco Nord Milano (Italy) combining lichen and tree response

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The huge and often unregulated urbanization that has been occurring in the last decades has changed dramatically the environmental conditions of previous rural and natural areas, with harmful consequences for ecosystem functioning and human health.

Urban green infrastructures represent a main mitigation measure able to reduce the impact of climate changes and provide ecosystem services. However, to evaluate and enhance the effectiveness of such strategies, it's necessary to assess the ecological status of urban forest species in the context of environmental restoration projects.

Parco Nord Milano (PNM), an urban forest plantation located in the northern part of Milan's metropolitan area, represents a case study where various methods and approaches were used to compare the status of forest resources at different time scales considering additional variables such as climate conditions, soil quality, and water supply.

This work aims at using lichens and trees to provide information on the long-term response of forest resources in PNM to the change of climate conditions and the impact of other biotic/abiotic stressors.

To that, we performed field data collection over three areas within a transect from the outer to inner zones of the park at increasing distance from a heavily polluted urban road. Lichens and tree cores were collected in order to analyze the impact of urban pollution on green areas.

On tree cores we measured annual growths and 13C and 14C carbon isotopes.

On lichens we measured total and functional Lichen Diversity Value, chlorophyll a fluorescence parameters, element concentration, and carbon and nitrogen isotopic signatures. Results are presented.

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Valuing part of London's urban forest – a comparison of methodologies

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The Victoria Business Improvement District (BID) lies at the heart of London in an area with very high real-estate values and a continuous cycle of commercial regeneration. Demand for space is exceptionally competitive and the justification for trees and greenspace is constantly challenged.

In 2012 the Victoria BID was the first in the UK to publish a green infrastructure audit, leading to significant investment in local environmental improvements. The BID's audit identified the importance of the mature urban forest, with the predominantly London plane (Platanus x acerifolia) canopy in streets and open spaces being recognised as providing a wide range of benefits. i-Tree was the system used to assess the economic value of the trees in the urban forest. However, for the non-tree elements, the GI-Val toolkit was used. As part of the EU COST Action FP1204, GreeninUrbs, further work was undertaken using the latest versions of i-Tree and GI-Val. A comparison of the cost of data capture, analysis and assessment of the results from the two tools was carried out.

Results showed that i-Tree provided data detailed enough to be used to inform management planning whilst also estimating the economic value of the urban forest. However, data capture using i-Tree was expensive and time-consuming. GI-Val provided less detailed data, but provided a wider range of tools and indicative economic values and the data took significantly fewer resources to gather and analyse. GI-Val also provided data on a wider range of green infrastructure typologies than i-Tree (eg green roofs, wetlands) but provided less accurate data on the structure and economic value of the green infrastructure.

Importantly, the study concluded that the two models are complementary and can be used in combination.

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What's in your back yard? Using citizen science to understand the contribution of domestic gardens to urban ecosystem services

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Domestic gardens and other private urban spaces provide a valuable contribution to the larger green infrastructure (GI) network in cities. Whilst comprehensive geospatial datasets for GI in public spaces often exist to aid GI planning (such as tree inventories), there is less knowledge and information available about domestic gardens. Given that domestic gardens comprise around 1/5 of the land area in cities, this represents a large gap in knowledge.

Furthermore, policymakers and practitioners often perceive it to be too challenging to influence the land management of these private urban spaces.

We present results of a citizen science project that aimed to improve our understanding of domestic gardens in a large city and the ecosystem services they provide, with a particular focus upon the benefits that enhance climate resilience.

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Estimating ecosystem services of air quality improvement and carbon sequestration by heritage trees in Macau

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Large and old trees are expected to provide more ecosystem services and equivalent economic values. The Urban Forest Effects (UFORE) model employs field assessment of tree dimensions and conditions and air pollution and meteorological data to estimate various ecosystem services of urban forest. The model was applied to 790 heritage trees aged ≥100 years in Macau to study their effects on air quality improvement and gross carbon sequestration. The results showed that overall 806.8 kg of pollutants were removed from air with benefits valued at $32 to $28,104 annually based on different monetary values of pollutants. The heritage trees stored 3040.8 t carbon in total, sequestrated 24.0 t carbon/year and provided $240 to $601 annual benefits. The values were much higher than ordinary urban-forest trees. The ecosystem services was estimated to be $0.3 to $36.3/tree/year. The common heritage species were ranked by their ability in air-quality improvement, carbon storage and sequestration. The data can serve as a decision tool for heritage-tree conservation and to estimate potential ecosystem services of established trees.

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SESSION 11
Assessing and mapping Ecosystem Services generated by urban GI

POSTER

Quantification of the Ecosystem Disservices of an urban forest in Northern Italy

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Studies on the ecosystem services of urban trees have increased steadily in the past years but scientists and city managers have an incomplete understanding of the role of ecosystem disservices, or costs, when assessing their overall net benefits. Urban trees, for example, can be indirectly emitters of carbon when fossil fuel is used for their maintenance. Wood waste is generated and pollutants are also emitted from pruning, maintenance and tree removal activities. Trees can also be related to human allergies (e.g. by pollen). Consequently, in order to assess the overall net benefits of urban trees, disservices such as wood waste from pruning and management, carbon (C) and air pollution emissions associated with tree maintenance and decomposition, increased energy use, and allergenicity must be considered. Such ecosystem disservices can then be balanced with ecosystem services to better assess the net benefits and cost-effectiveness of sustainable urban forestry. This study will quantify key urban forest ecosystem disservices in the City of Merano in the Southern Alps (N Italy). Tree inventories, a life cycle approach, maintenance surveys, ecosystem services models, wood-waste quantification, and urban design elements will be used. These estimates will provide up-to-date and management-relevant information on the overall net benefit of urban forests. Methods, findings and metrics can be used to help city managers minimize these ecosystem disservices and costs such as CO2 emissions, air pollution emissions, and allergies from urban tree management in the cities of Europe and elsewhere.

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Towards and integrated assessment of urban ecosystem services

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Urban and periurban green (and blue) infrastructures (GI) deliver multiple benefits to human societies, ranging from environmental services (climate and water regulation, mitigation of air pollution, etc.) to socio-cultural benefits and opportunities (leisure, health and well being, environmental education and research, urban landscape beautification, heritage and identity, etc.). This multifuncitonality is the very added value of green infrastructures, and what makes them a strategic asset for the future sustainability agenda of modern cities, increasingly pressed by the unpredictable pace of global change. A variety of valuation methods and assessment techniques have been developed so far, and many models and tools are available nowadays to estimate the contribution of GI to urban environmental quality. However, their effectiveness to actually influence local GI policies and strategies remain uncertain: local administrators are often unable to transfer scientific data into concrete measures to be implemented at the municipal level, and the scientific evidence for GI remain an unlearned lesson in many cases. Aim of project is to develop an easy, integrated, ready-to-see-and-use way to represent the potentiality of GI (urban green, agricultural and natural protected areas, etc.) to deliver essential urban ecosystem services (UES): micro climate regulation, water drainage, habitat & biodiversity, food production, health & well being, environmental education. Six major Italian cities have been selected to test the project. It is argued that representing multiple UES in a one-shot figure, not necessarily given in quantitative and/or economic terms, may help stakeholders in understanding the key role of GI services and values for essential domains of human quality of life.

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Introducing landscape connectivity assessment in urban planning: the case of Bari green infrastructure

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Traditional approaches to the biodiversity conservation look at the connectivity among hotspot habitats often located within protected areas and Natura2000 sites. However, in a context of increasing human dominated landscapes as cities and megacities, where built up and rural and protected areas are fast moving closer to each other, large portion of territory could be excluded from these connectivity evaluations.

Green Infrastructure (GI) planning offers the opportunity to abandon the traditional conservation of biodiversity islands towards a more holistic and wide strategy of diffuse landscape connectivity assessment for Ecosystem Services preservation and enhancement even in urban/human dominated landscapes.

The metropolitan area of Bari has a reduced and disconnected GI. Indeed, the urban expansion and road development defines a relevant landscape fragmentation. Peripheral agricultural territories have been progressively converted in urban area and the remaining rural areas suffer the urban pressure. New urban settlements should be planned reducing as much as possible new soil sealing by filling urban empty spaces. According to the Regional Landscape plan, agricultural/urban parks should be planned in order to reduce habitat fragmentation and increase the biodiversity. Moreover, the preliminary Master Plan of Bari reports a reduced ecological value of the whole landscape mosaic. The need to define a city sustainable development offers an interesting study case for the evaluation of the urban landscape connectivity.

Recently, an innovative free and open model (PANDORA 3.0) for the assessment of Bio-Energy Landscape Connectivity (BELC) and related ecosystem services for biodiversity conservation has been presented. In this paper, the model implementation on a typical urban planning context (Bari Metropolitan area) has demonstrated the capability of PANDORA in evaluating different typologies of areas not still urbanized in terms of ecosystem services giving information on their contribution to system connectivity and biodiversity conservation.

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Measuring the amenity value of urban greenspaces

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Ecosystem services in an urban context are defined as the benefits nature give to society and have become the lingua-franca of both conservation and policy agendas. Regulatory and provisioning ecosystem services have been regarded as easier to measure and value; they have therefore been more widely investigated than cultural services. However, in the urban area cultural services are often those most appreciated by the local community. We propose to improve the measurement of cultural services utilising models developed for commercial applications.

This study uses a model based on the Huff's probabilistic model. It describes consumer behaviour when selecting a destination from a range of potential shopping locations. In the model, the effective gravity or attractiveness of greenspace increases with increased amenity; destination is therefore a function of amenity and distance. The model is probabilistic in that is does not assume a single solution, i.e. the existence of a large park does not mean a smaller equidistant park will not be used; instead it suggests that more people will visit the larger park.

We propose to create profiles for different greenspace sizes (Small, Medium, Large and Destination) which control the distance travelled, duration of visit, frequency of visit and type of travel used to access the greenspace. The recreational value of greenspace being expressed as function of visitor numbers, duration and frequency of visit.

Using this work we expect to be able to predict the number or people using different greenspaces and to estimate its recreational value. In addition we will be able to identify communities with insufficient greenspace provision and help planners to maximise the impact of future interventions.

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The green side of the grey: an innovative approach for large-scale monitoring of Urban Green Spaces

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Urban green spaces (UGSs) are 'green' lands in 'grey counterparts' built-up areas, whose social, economic and ecological benefits for human health and wellbeing are widely recognized. Accordingly, the assessment of their extension, structural and spatial characteristics, as well as their ecological functions, has a key role in supporting the future urban policy and planning. However, large-scale data and information on UGSs are still lacking. This study aims at developing and testing an innovative and cost-time saving approach for achieving large-scale statistically-sound estimators for UGSs with particular regards to their structure (i.e. abundance, coverage, average size and tree cover density) and ecological functions (i.e. number of people leaving in their proximity and related ecosystem services provision). The proposed methodology has been tested at national scale in Italy, and it is based on the integration of the inventory and cartographic approaches. According to the high spatial resolution of the land cover map that we used, very small UGSs, defined as areas dominated by trees or grasses, were also included in our evaluation.

We found that UGSs cover about 170,000 ha, largely dominated by forests (89%) and, secondarily, grasses (11%). A rural to urban gradient was also found, thus demonstrating the increase of UGSs when moving outside from densely-populated areas. In fact, UGSs are widely represented by forests in rural areas, while those located in peri-urban and urban areas only account for approximately 1/3 of the total UGSs' surface. Similarly, the average size of UGSs and the *per* capita UGSs' surface decreases if passing from scarcely- to high densely-populated areas. Further than the low costs for realization and updating, our approach is demonstrated to be suitable to provide reliable UGSs estimates, and offers some first insight on their ecological functions. This information may be considered a valuable support, as it seeks to incorporate the ecological principles within the land use planning processes, through considering an urban–rural *continuum*.

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Assessing the landscape resilience of urban open space --- two case studies in Dublin

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The world is changing, driven by such forces as urbanisation and climate change. This results in unexpected disturbances that people cannot control. In this context, urban open space has to accommodate more functions to deal with these uncontrolled and often unanticipated changes. Significance advances in the concept of resilience, emphasing the ability of adaptation against uncertainties, have recently been made through transdisciplinary collaborations among researchers, professionals, decision-makers, and stakeholders. This paper offers an insight into developing a tool trying to measuring landscape resilience. This approach uses a hierarchic index system including 26 sub-indicators, distributing weights of each indicator by an analytic hierarchy process, and using the weighted sum model for composite calculation. This approach is demonstrated in a comparison of two study areas in Dublin, Ireland. The selected indicators used in this approach are associated within the social-ecological system, referring to benefits of ecosystem services and landscape connectivity. The proposed method, adopting a transdisciplinary approach, provides a useful tool for planners and landscape architects to evaluate existing schemes and new proposals, and to assist policy makers and those with responsibility for the implementation and management of new urban open space by providing quantifiable evidence to support their decisions.

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SESSION 12
Sustainable management of GI

ORAL

Keynote Speaker
Green Infrastructures: a sustainable management approach

Francesco Ferrini, Alessio Fini*
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Though urban trees are increasingly recognized as more than just green relief amongst buildings and other built (grey) infrastructure of cities, the investments in planning and managing urban trees, grown on public land, compete for limited local government funds in many cities around the world.

Strengthening green infrastructure is fundamentally about making the most of existing assets and it can transform the quality of places. A strategic approach to the management of GI aimed to maximize tree growth and physiological performance can have a profound effect – not only on the way a place performs, physically and economically, but also the health of those who live and work there. Unfortunately, the approach in too many cities has been to remove trees rather than to find ways to redesign structures to be compatible with trees.

Actually, green infrastructure quality and duration depends initial planning and on appropriate long-term management and maintenance of the site's vegetation accompanied by maintenance schedules, to ensure that these interventions continue to be effective in the future.

The presentation will then put emphasis on the relations between technical infrastructures and vegetation. It's important to improve all aspects about site conditions and how select tree species well-adapted to the urban environment. This needs to be based on comprehensive inventories of the urban tree resource and should assess the aesthetic, social, environmental and economic functions of the urban forest.

New techniques and new soils to improve tree growth and to avoid tree conflicts with the built environment will be discussed with a special emphasis on soil covering materials.

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Growing the Urban Forest resource: the art and science of planting a tree

*Naomi Zürcher**

Sustainable urban ecosystems are synonymous with vital and sustainable communities, based on ealthy environments. A crucial part of any municipality's environment is its Urban Forest.

The growth and development of an existing Urban Forest is the result of the interaction between genetic potential and surrounding environmental conditions.

In traditional forests, where most of our urban trees originate, this interaction is fairly stable. In an urbanized area, stability is an anomaly and most of the out-ofbalance variables are not tree friendly.

There is a direct correlation between the structure of the Urban Forest and the benefits it affords its residents. If the Urban Forest resource is to be planned and managed according to its needs and ours, we must not only asses the what that exists but we also need to develop a working Toolbox – Standards, Protocols and BMPs - guidelines which can help define strategic plans and goals.

In developing these guidelines, it is critical to explore an essential component of growing the Urban Forest resource – how we plant an urban tree. While it looks quite simple and has often been touted as such, this suggestion belies the complexity of the organism itself. There is a great deal to consider in the entire process of planting a tree, so that at the end of that process, we DO have the right tree in the right place with the potential to thrive and deliver the extensive array of Ecosystem Services we expect and require.

This practitioner presentation will offer insight into the art and science of planting an urban tree:

• actionable strategies and procedures fundamental to successful planting for the long-term;
• steps needed to create a broad, informed base to support the process;
• guidelines that define the actionable strategies and procedures and how they can be realized to reach quantifiable goals.

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Drought and flood resilience in an existing urban forest

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Embedding resilience within ecosystems is seen as one of the key challenges of our time. While many people have looked at emerging threats, for example pests and diseases or climate change; fewer have considered urban forest resilience to existing threats. In this study we aimed to assess the drought and flood risk for individual trees in one urban forest.

Shettleston, a district in the east end of Glasgow, Scotland was used as a study site. A government tree inventory was used to identify the species present in the area and these were ranked in terms of their flood and drought tolerance, based on information collected from published literature. All trees were rated from 1(Very intolerant) to 5(Very tolerant) for both categories. Tree locations were compared to flood risk maps and soil moisture deficit datasets to identify trees that are at risk from flooding and if these belong to known flood tolerant species. Although Shettleston's urban area is perceived to be at greater risk from flood events, we expect all urban trees to experience some drought stress.

We found that 10% of Shettleston's trees are growing in a flood zone, of which 1% is at high risk of flooding (i.e. 10 year return period).Shettleston's tree stock is relatively intolerant to flood or drought, with mean tolerance ranking values of 1.9 and 2.6, respectively. The research also indicated that the existing tree stock had been poorly spatially targeted within the environment.

Utilising publicly available data and the techniques described we were able to identify individual trees, as well as species and genus categories, at risk from flooding and drought within the study area. Furthermore we could identify suitable trees species and spatially target them in the landscape to improve future planting regimes

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A case study showing the application of modern urban forestry principles and thinking in the preparation of an urban tree strategy

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In the preparation of a tree strategy for a London Borough, modern principles and thinking in urban forestry and urban greening practice were applied. The Borough proved an interesting study due to significant differences in architecture, development and demographic patterns between the northern and southern sections, which are divided by a major strategic road. Data on health and income showed wide variations within the geographical area and surveys of environmental (principally traffic) pollution identified areas of particular health concern, including the urban 'heat island effect'. The Borough is a designated Air Quality Action Area. Data were compared with geographically referenced tree population data to identify weaknesses within the urban forest structure and to suggest areas for regeneration and enhancement. The exercise was approached so as to persuade decision makers of the absolute necessity of maintaining and improving urban forest coverage at a time of economic stricture.

The strategy addressed problems posed by highway management issues and by the Authority's ownership of trees on land within the control of other actors. The holistic approach to tree management and the identification of eco-system benefits and likely contributions to public health ensured that co-operation was forthcoming from allied departments within the Authority. In addressing species for new planting, emphasis was placed on the selection of species known to contribute environmental and eco-system benefits, particularly in combating pollution. The case for trees was strengthened by reference to empirically-defined data arising from the considerable amount of research both by workers in the urban greening field, but in other relevant fields, in particular, that of medicine (both physical and psychological), which has taken place in recent years.

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Is the management of Britain's urban forests really sustainable? Time to take an ecosystem services approach

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Urbanisation and a changing climate are leading to more frequent and severe flood, heat and air pollution episodes in Britain's cities. Interest in nature-based solutions to these urban problems is growing, with urban forests potentially able to provide stormwater attenuation, heat amelioration and air purification benefits. The extent to which these benefits are realized is largely dependent on urban forest management objectives, the availability of funding, and the understanding of ecosystem service concepts within local governments. This study aims to establish the extent to which British local authorities manage their urban forests for regulating ecosystem services, and what is needed to improve the situation.

Interviews were carried out with staff responsible for tree management decisions in fifteen local authorities from across Britain, selected due to their high population density. We find that local authorities have a reactive approach to urban forest management, driven by safety concerns and complaints about tree disservices. There is relatively little focus on ensuring provision of regulating ecosystem services, despite awareness by tree officers of the key role that urban forests can play in alleviating air pollution, flood risk and urban heat anomalies. This is largely due to funding constraints, limited political support, and poor understanding of ecosystem services amongst decision makers and other stakeholders. We suggest that the use of tools that quantify and value urban forest-based ecosystem services, the adoption of proactive urban forest strategies, and innovative funding mechanisms that involve the private sector, can facilitate the change from reactive urban forest management to a more sustainable, ecosystem services approach.

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Ecosystems services provided by small urban green infrastructures – case study Bucharest

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The importance of green areas in providing a variety of ecosystem services at urban level is well recognized both at scientific and administration level. Romanian legislation divides into categories green areas inside the cities only after their accessibility: spaces with public access (such as parks, public gardens) and spaces with special access (botanical and zoological gardens, museums, green areas around public institutions, private leisure areas, and sport facilities).

Our analysis used the spatial distributions of green spaces around public schools, sport and leisure facilities, commercial areas in Bucharest and questionnaires applied to both their managers and users about the perceived benefits and disservices such spaces bring at ecological, economic and social level. Results reveal that this type of special access areas bring advantages especially for the quality of green areas, present a larger variety of ecosystem services (educational services for school gardens, aesthetics and infiltration for commercial areas), but in the same time represent a challenge for integrative planning and strategies at urban level.

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Monitoring of GI-management based on maintenance-logics

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Monitoring of maintenance is a key issue for management of GI, but we lack established systems and methods for monitoring. SLU Alnarp has developed a model for monitoring – the maintenance-logics – based on a model for logics of effects. The maintenance-logics consists of four steps for understanding of the content in all kinds of steering documents used for maintenance:

resources → activities → results → effects.

The maintenance-logics reflect all kinds of statements and regulations used in the steering documents and should be the logics used for monitoring to create a clear relation between documents and monitoring. On the other hand, the steering documents should not contain any regulations that is not possible to monitor or for one reason or another is not used for monitoring. The model has been used in a study of seven Swedish management organizations representing three different parts of GI: municipal parks (2), housing areas (3) and churchyards (2). Out of those five have their maintenance outsourced and two in-house. The steering documents from each manager has been studied and structured through the maintenance-logics and a template for monitoring has been formulated and tested in practice. Our study shows that the steering documents must be developed, simplified and made more clear if they shall be possible to use as a base for monitoring. The maintenance-logics offers a clear and pedagogic structure but it is a huge task to develop the steering documents to create mutual understanding between the parties (either they have an in-house or an outsourced realation) and form the base for monitoring. A basic problem is that the terms does not come from a joint and well-defined professional language, but are fetched from the everyday language.

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Spatial indicators for smart urban green spaces management

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The availability of accessible and attractive Urban Green Spaces is an essential element for the quality of life of urban inhabitants. Improving environmental conditions through the provision of ecosystem services and nature based solutions, UGS create healthier and more sustainable environments and lifestyles. The role of UGS and their ability to provide benefits to the urban population is closely related to the quality of their management. Maintaining high quality UGS has become an issue as important as increasing their presence and improving their accessibility to citizens. UGS management is however currently under pressure because of wide-spread cuts in public spending, inefficient governance at national or local levels, and lack of citizen involvement.

The UGB Central Europe Interreg Project aims to develop integrated GIS-based models and tools for managing urban green spaces smartly and test the elaborated solutions through pilot actions in the participating countries.

Within this context, our working group is developing a set of environmental, social and economic indicators that, respecting the multifunctional value of UGS, can accurately point out positive and negative effects of planning and management activities. For the practical application, the design of an innovative monitoring tool using GIS technology is envisaged. The short paper (?) presents a first application of some derived indicators in a study area in the city of Padua with possible use cases for testing the outcome of different management scenarios.

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Sustainable management of green infrastructure: state of the art in 116 major Italian cities

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Functional and healthy public green areas need adequate policy instruments and management tools, which can support local administrators in integrating green infrastructures into the urban agenda. Since 2004, the Italian Institute for environmental protection and research (ISPRA) yearly monitors the level of implementation of three major policy instruments for public (and private) green management and planning: green census, green ordinance and green master plan. Data, collected by the National Institute of Statistics (Istat) directly from the major 116 Italian municipalities show that at the year 2015 the Green Census (inventory) is the most widely adopted tool (89 cities out of 116), though a big part of them (42) regard only a part of the public total green and need to be further extended. Green ordinances are adopted in 52 cities, concentrated in the Center-Northern area of the country, and mostly in the period 2010-2014. On the other hand, only 11 cities have a Green master plan, a (voluntary) planning instrument which not only aim at the requalification of actual green but also define a medium-long term strategy of what, which and where (and possibly how) public green areas will have to be developed in the future, as long with land development and transformation.

Data seem to outline a picture where green spaces are mainly managed with a technical/prescriptive approach, considered a management problem rather than a strategic asset for more resilient cities. It is argued that local policies for green infrastructure need stronger public engagement and institutional commitment so as to ensure more resilient and livable cities to increasingly urbanized future societies.

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When Inonotus rickii meets Celtis australis: a constraint on the use of hackberry trees in Lisbon

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In Lisbon, among the 45,000 existing street trees, Celtis australis, Platanus spp. and Tilia spp. are the most relevant species used in urban green infrastructures. The dominance of only three species increases the risk concerning the attack of new pests and diseases. Currently, 9,000 hackberry trees are threatened by the aggressive basidiomycete Inonotus rickii (anamorph: Ptychogaster cubensis).

Identified for the first time in Portugal in 2000, I. rickii causes white rot and canker and affects young and adult individuals. This fungus causes rot of the heartwood in branches and trunks putting people and goods at risk. Other mediterranean countries, such as Spain, Greece and Italy, also reported I. rickii affecting species like Acer negundo, Robinia pseudoacacia and Styphnolobium japonicum. Furthermore, this decay fungus is already spread across many other countries like Argentina, U.S.A and China.

In this study 374 hackberries were analyzed with the main goals of evaluating the presence of I. rickii and to assign a risk of failure to each tree using the Visual Tree Assessment protocol (VTA). Comparing results from 2007 with the present ones, the incidence of the disease increased 10% with 15% of the trees having basidiomata or brown powdery masses of chlamydospores. The lack of appropriate management decisions regarding tree pruning care and elimination of basidiomata in affected trees, together with favorable climatic conditions apparently worsened the phytosanitary situation of hackberry trees in Lisbon.

In Lisbon this fungus is considered one of the most economically important decay polypores, causing trees to be hazardous and endangering the continuity of C. australis in the planning of future green infrastructures.

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The impacts of waterproof surfaces in trees

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Trees are structuring elements of green spaces and the environmental, ecological, landscape, psychological and emotional comfort benefits increase in the same proportion of their size. By this reason. big trees are essential in green spaces and requalification interventions should improve their overall condition.

As a result of several studies, it has been found that in Portugal it is very common to use material that contributs to soil waterproofing. These constructions often involve: 1- Ground mobilization; 2- Use of heavy machinery; 3- Opening of trenches to install infrastructures; 4- Installation of waterproof surfaces.

The use of construction materials to facilitate people's mobility often omit aspects of biological nature of vegetation. Failure to consider these factors, such as the need for root expansion, the respiration and the importance of entry water and nutrients into the soil, beyond the tree canopy projection area, makes it impossible to have trees in good condition. This procedures contributs to ecological devaluation and the quality of people life.

The studies developed in several Portuguese cities showed that the impermeable surfaces and soil compaction are the factors that most contribute to the decline of the trees. Unfortunately the symptoms are often only noticeable 2-3 years after the work is done. This is why the impacts of waterproof surfaces on the trees are not always recognized.

On the other hand, there are technical solutions that allow the permeability of soils and the circulation of people. Some cities such as Ponte de Lima, Porto or Freixo de Espada a Cinta have opted for soil cover solutions that fulfill those two functions, with the corresponding ecological benefits and people's quality of life.

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State of Swedish public parks - the basis for future developments

Thomas B. Randrup, Johan Östberg & Björn Wiström*
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This presentation will discuss the status of Swedish green space management practice as a basis for future development of green spaces and thier use.

In Sweden, almost 1,7 billion Euro's are used annually to manage urban green spaces. This amount is distributed among at least 40,000 organizations, incl. local authorities, housing companies, estate companies and regional authorities. This rather complicated and fragmented green space management structure in Sweden is comparable to the other Scandinavian countries.

The objective with this study was to undertake an assessment and analysis of the key issues and challenges that public parks in Sweden are currently facing. By focusing on a broad range of information relating to both finance and resourcing; the quantity and quality of parks being managed; organisational arrangements for maintenance; information on park visitors and volunteers; and, issues of strategic policy we have developed a framework, which will make it possible to discuss and develop the future of public parks in Sweden on a higher level.

In general, the current status of the Swedish green space management situation is optimistic. However, approximately 18,6% of Swedish green space managers have experienced their budgets to decline during the last three years, and 22,3% expects this trend to continue in the near future. About every 6th municipality has experienced a decrease in staff, and at the same time, 60% of all managers state that the current funding situation is below what is sufficient for an upkeep of the current management level. Funding from other sources than the taxation, as well as active participation from users, is limited, and poses a potential for future cooperation and development of Swedish green space management.

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Health village of Saracinesco

*Roberto Fagioli**
Forestry engineer and landscape architect

This project is an example of possibilities for create and build green infrastructure and related areas through looking for funding multidirectional togheter to private entities (associations, private investors, company producing goods and services) and public istitution. This pathway involves also the citizens and stakeholders from the beginning to the end, and after during phases of maintenances.The project was conceived in the town of Saracinesco situated about 100 km from Rome. The idea was to create a clinic to accommodate people with complex diseases and cure them or assist them through the use of natural medicines extracted from aromatic and medicinal plants. Among these plants the main one is the use of cannabis for the extraction and use of cannabinoids (without TBC) in the treatment of many diseases.The project wants realized an ecological structure with the use of biological building materials.

This consists of a main reception center and a number of smaller apartments to accommodate patients, equipped with all comforts and a private vegetable garden. Is part of the project the creation of a multidisciplinary park along the Aniene river, 30 hectares of land to be used in part for crop production (cannabis and herbs) and in part to urban park where to do various activities: walking, horse riding, fishing, games and to do scientific research on flora and fauna typical of the river environment.The site that hosts the project has two scenarios: the mountain and river, two contexts that help the sick in the course of treatment. This project was designed togheter to two universities (specialized in medical and agronomic research), with the participation of the Italian Society of Natural Medicine and associations of sick.

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SESSION 12
Sustainable management of GI

POSTER

Urban forestry development in Albania, a review for capital city Tirana, the status, the problems and the future challenges

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Albania, a small, but a very beautiful country, is located on the Balkan Peninsula, on the south-eastern part of Europe.Terrestrial, sea, rivers and lake form are main kinds border that enclosed Albania. Different plants, natural habitats and ecosystems exist in Albania as: shrubs, broadleaves, conifer, and mixed forests, pasture, meadows, rocks, coastal, lagoon area, marine, lakes, rivers, agricultural and of course urban areas. In here we have about 30% of European's flora, around 30 endemic and 160 sub-endemic species. Around 36% of total surface of Albania are covered from forests, and 12.6% are Protected Areas, according to IUCN criteria.

Last decades, in Albania have a new concept,rather different from tradicional defination for the forests.Nowdays, we do not call forests only those grown in wild forms but also those that grow in urban/periurban areas, as a result we have a new concept for development of urban/periurban forests, their governance and management. More concretely, urban/periurban forestry appears in a some big citys in Albania as Tirana, capital of Albania, at Korca,Elbasani, Shkodra, Vlora but and in some small citys as Pogradeci, Lezha ect.

Urban forestry in Albania egzists in all forms; as forest in urban areas,trees planted in the street,tree groups in public and private areas etc.Are planted many kind of trees, including broadleaves, conifers, shrubs. In some citys is made a simlpe inventorie of trees. But, of course development of urban/periurban forestry in Albania have and many problems and challenges for in the future.

Finally, actual situation of urban forestry deveopment in Albania, chellenges and their perspective in the future, some of them will be treated in this paper.

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Analysis of spatial distribution and availability of green areas in the city: a case study

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Green areas constitute a very important part of the city's urban programme. Apart from providing the residents with the possibility of contact with nature, greenery primarily weakens the negative impact of the urbanised environment on the residents, influencing the comfort and the quality of life in the city. One of the greatest problems of the dynamic development of some cities is the insufficiency of green areas; therefore, it is important to define the significance, the quality, the quantity, the distribution and the availability of green areas in urban layouts. The article presents and evaluates the spatial distribution of urban green areas within the administrative borders of Tczew, located in northern Poland. Their diversity, condition and availability were taken into account. Unequal distribution of green areas in individual housing estates of the city and differences related to various levels of their quality and availability require activities aimed at eliminating such adverse phenomena. The development strategy of green areas will significantly influence the improvement of green area management processes in the city.

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Tree assessment for safety condition of urban parks in Porto city

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Phytosanitary assessment and inventory of trees are important tools to help the management and organization of all activities to improve quality and safety of Urban Forests.

In Porto city, the Urban Forest, namely the urban parks, have been monitorized. Phytosanitary studies were performed by University of Trás-os-Montes and Alto Douro in cooperation with the Porto City Council. The aim of this work was to qualify, mapping, and organize all the information, namely the safety condition of the trees, included in a Geographical Information System (GIS).

The evaluation, includes the tree ID, related with the geographical position. This information can be assessed by a label, with a Quick Response Code (QRC), located in almost 50% of the trees. The QRC conects to a database with all data. Data can be assessed by the professional's team from City Council of Porto, in real time. The public can also acess to part of this data by the QRC connection.

Until now, the survey of dendrology parameters, phytosanitary condition and tree environment, characterized almost 4.500 trees, in a 25.000 universe. The system accounts to a field real time registration, by smart phones or tablets, connected to the database.

The "Palacio the Cristal", "Mata da Pasteleira" (already evaluated), and "Parque da Cidade" present different trees density, species and management. In this parks, the methodology used identified several trees with risks to fall and with phytosanitary problems, referenced in GIS.

The survey could prevent identified risks and improved the quality of field work, namely pruning, cutting trees and new plantations.

Based in the same goals, other cities from Portugal are interest to implement a similar methodology to collect similar qualitative and quantitative parameters.

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Trees of Public Interest in Portugal: obstacle or advantage to modern green areas?

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In Portugal the protection of trees standing out due to their size, age or botanical rarity date back to 1910. The process of protection was regulated by law only in 1938, and during almost 40 years the "Instituto da Conservação da Natureza e das Florestas, IP", the entity responsible for the recognition and protection of these trees, classified around 500 trees, both isolated and in groups, belonging to several species. With the increasing interest of people for green spaces in cities and specially the attention they pay towards old trees that represent a connection with the nature and the history, the old law became obsolete.

The protection of trees of public interest in Portugal is nowadays regulated by the Portuguese Law number 53/2012. Under this legislation a public data base, named "Registo Nacional de Arvoredo de Interesse Público" (RNAIP), is maintained, with the aim to present all the classified trees and their characteristics, enabling people to profit from this valuable legacy. Presently, the RNAIP includes 591 entries regarding 507 isolated trees and 84 groups of trees along boulevards, streets or in small peri-urban forests. Lisbon is the region with more classified trees, in a total of 137 individuals, followed by Leiria (67) and Oporto (45). Most of the Portuguese classified trees are angiosperms (337) although some gymnosperms, such as Pinus pinaster, are well represented. Worth of mentioning is also the fact that, among the isolated trees classified, around 10% are Quercus suber, species considered as the national symbol of Portugal.

Under the present work we discuss how the law that classifies and protects monumental trees should drive technicians and politicians to recognize that old trees are compatible with new, modern green infrastructures.

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The practice of urban forest management: Langervalde forest, Latvia

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Urban forests play an important role in providing environmental, social and economic benefits as well as in improving the quality of life and human health in urban landscapes. It is known, that urban forests provide many ecosystem services with relevant monetary value.

Therefore long–term management of urban forests is required for the provision of these services. Urban forestry is multidisciplinary and often numerous stakeholders are involved in land planning and management process. Due to usage intensity and diversity of users, urban forests are frequently called "hotspots" for development and adaption of innovative forest management practices, which may improve benefits such as opportunities for recreation, aesthetics and the quality of life. Langervalde urban forest is a eastern part of Jelgava city, Latvia - forested area with size of 50.3 ha. This place historically has been recreational area within the city. Our study investigates the methodology of integral forest management and latest technologies in the management of urban forests. In this study integral management system for ecological, economic and social values of urban forests are studied, including the technologies for inventory, planning and felling. As the outcomes of this study, recommendations for sustainable and multifunctional management of urban forests and instructions for selection felling will be prepared, as well as demonstrated on an experimental management site. This approach and technologies will ensure the sustainability of social and environmental functions and will increase the efficiency of forest management actions.

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Determining Potential Greenway Trails of Turkey

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Turkey has not enough landscape planning and management strategies. Therefore natural, cultural and historical landscape values are under threat because of unsustainable land use decisions. At this point, greenways planning strategies are well known way to protect landscape values depends on landscape ecology. Turkey has valuable landscape values with forest, rivers, sea, flora, fauna topographic, geomorphologic structures, historical ancient, historical trails, local-cultural property. Nevertheless they have not link among them therefore they are faced with the risk of loss.

The aim of this study is to offer potential greenway trails for Turkey depends of national parks, protected areas, forests, heritage areas, urban green parks, ancient values, historical trails and roads separately. Through this approach, sustainability strategies of the each greenways are defined as part of landscape planning and then explained the future contribution for urban and rural areas, for locals and for landscape ecology of Turkey. To reach of this aim, the contribution of greenways strategies determined with greenways trails and greenways criteria. For this reason, the most known greenway projects in the world were searched and the greenway criteria and characteristics of them were listed. Firstly, the greenways proposal trails of Turkey were selected and then mapped in GIS environment. Consequently, the contribution criteria of each trail was listed for protecting sustainability of natural, cultural and historical landscape values and for improving public awareness in Turkey.

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Water management of green roofs in semi-arid urban environments

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Green roofs are being increasingly used in urban environments for their multiple benefits, including stormwater retention. The increase of impermeable areas and an inefficient stormwater drainage network causes flooding problems in the urban area of Nicosia, Cyprus. The implementation of green roofs could reduce the volume of stormwater runoff and mitigate floods. However, long dry periods make it difficult to maintain plant life on green roofs without irrigation. The aim of this research is to study the stormwater retention and plant performance of green roofs in a semi-arid environment. An experiment, which was set up on the roof of a three-storey building in Nicosia, examined combinations of different types of substrate mixes (Mix1 and Mix2), drought-tolerant plant species (native Frankenia Laevis and endemic Euphorbia Veneris) and deficit-irrigation levels (15 and 30% of reference evapotranspiration) with corresponding replicates. The substrate Mix1 comprised of pumice(0-8mm):pumice(5-8mm):zeolite:soil:compost (25:30:15:15:15 v/v) with a depth of 15.5 cm and Mix2 of perlite:pumice(0-8mm):pumice(5-8mm):zeolite:soil:compost (12:27:13:22:13:13 v/v) with a depth of 17.5 cm. An average stormwater retention of 71% for Mix1 and 88% for Mix2 was achieved for a rainy 3-day period of 41.3 mm. During the June to October irrigation period, the plants under the 15% evapotranspiration irrigation level had a low survival rate. Overall, it was concluded that green roofs can be a promising urban green infrastructure for stormwater management in semi-arid environments, but further research on deficit irrigation is needed.

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Analysing of Cittaslow (slow city) movement in the context of landscape indicators in spatial planning: In case of Cittaslow Turkey

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With the impact of globalization cities are transformed into living spaces that are non-self-sufficient, hovewer sustainable planning principles emerge as opportune ways to improve the cities.The aim of the study is; in the context of Cittaslow movement developed from the urban sustainability principles, determining a method for the landscape values of the cities declared as Cittaslow and suggesting new parameters that may be an output for the existing slow city criterias.

The study is a response to the main questions "How slow cities lead to the future of urban areas?" The auxiliary questions that produce solutions to the main objective are; What is the situation of slow cities in Turkey in terms of spatial planning , How can slow cities contribute to spatial planning when they are explaining with landscape indicators?

In the method of the study, the literature survey prepared on the Slow city (Cittaslow) movement is explained with the landscape indicators in the context of spatial planning principles. In the sample of slow cities in Turkey, the morphological analysis of the cities is carried out and the present situation is determined as a result of quantifying the spatial values. If the spatial values of the slow cities are quantified, if the criterion is insufficient, suggestions are added and improvements are made.

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The connection between Campus Greenways, recreation, and education

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Ideal campuses should provide its users a campus environment with a wide social world in addition to educational and training programs. It should include places that will have a positive effect on the personal development and socialization of the students and their being successful and productive. Creating greenway systems as alternative road pathways generally makes cities more accessible and increases the life quality of societies. Greenways connect the city with the rural area, people with nature, and a natural area with another one. These routes are in the form of outdoor classes that give information about natural systems. They may provide educational information that will contribute to the protection and improvement of the areas they get connected to, in line with their properties. Campus greenways will give a new impetus to education by supporting working, learning and discovering, helping to investigate and providing a space for open-air discussion areas with training possibilities. It will be a tool for creating a quality physical environment by contributing to obtaining good habits with recreational activities such as walking, running and cycling.In this study, the relationship between recreation and education will be investigated in the context of a greenway planning approach in the form that can support the education and training activities in parallel to fulfilling the recreational needs of campus users.

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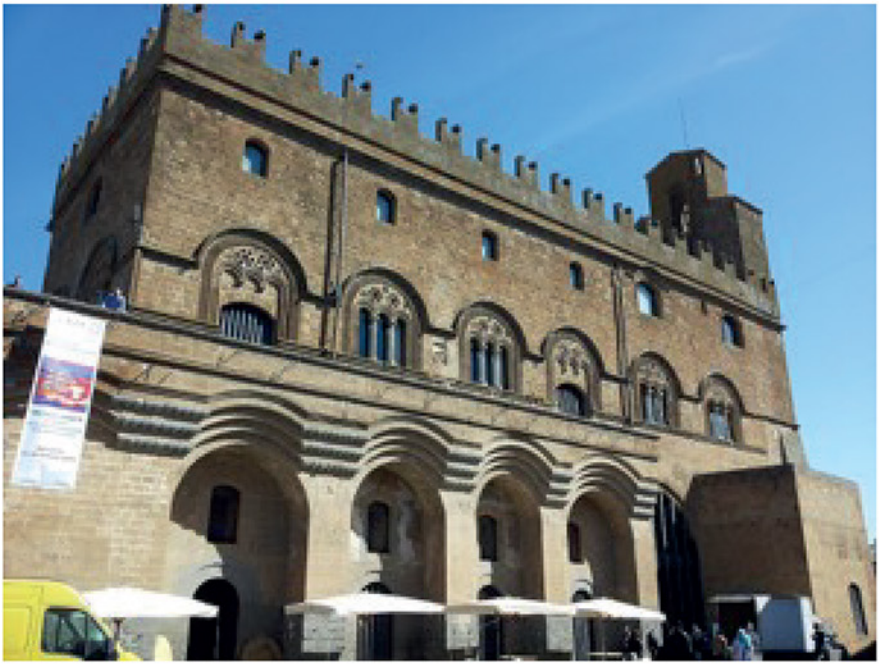

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