European Commission

NWRM

Natural Water Retention Measures

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Individual NWRM

Trees in urban areas

Environment

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I. NWRM Description

Trees in urban areas can have multiple benefits related to aesthetics, microclimate regulation and urban hydrology. Trees in urban areas can also be important biodiversity refuges and can contribute to reducing particulate air pollution. Trees intercept precipitation, reducing the amount of rainfall which must be processed by sewers and other water transporting infrastructure. The area around urban trees may also have greater infiltration capacity than the impermeable surfaces often found in urban areas. Trees also transpire, which dries the soil and gives greater capacity for rainfall storage.

II. Illustration

Trees in Fayetteville, USA

Source:
http://www.accessfayetteville.org/government/parks_and_recreation/park_planning_and_urban_forestry/urban_forest.cfm

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	Yes	This measure is only relevant in urban areas, thus it is suitable for artificial surfaces.
Agricultural Areas	No	This measure is only relevant in urban areas.
Forests and Semi-Natural Areas	No	This measure is only relevant in urban areas.
Wetlands	No	This measure is only relevant in urban areas.

Region	Applicability	Evidence
Western Europe	Yes	This measure is possible in cities throughout Europe. Ideally, any new planting should use native or indigenous species.
Mediterranean	Yes	
Baltic Sea	Yes	
Eastern Europe and Danube	Yes	

IV. Scale

	0-0.1km^2	0.1-1.0km^2	1-10km^2	10-100km^2	100-1000km^2	>1000km^2
Upstream Drainage Area/Catchment Area	**Yes**	**No**	**No**	**No**	**No**	**No**
Evidence	As with urban forest parks, it is difficult to place urban trees into a catchment context. The benefits of urban trees are extremely local. Hydrological benefits are related to increased interception and evapotranspiration. Urban trees can also play an important role in moderating local microclimate and can contribute to groundwater recharge. Urban trees can also be very important for increasing biodiversity in urban areas. The biophysical impacts of individual trees are generally low but as these impacts occur over a very small area, they can be locally important.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	Medium	Because the area around urban trees is often more permeable than areas further away, urban trees have a moderate potential to store runoff. The runoff storage effect is likely to be extremely limited and localized for each tree but groups of trees or small urban forest parks could have a demonstrable effect on storing runoff in urban areas.
	Slow Runoff	Medium	Individual trees will have a real but limited ability to slow runoff in urban areas. The rougher, more permeable soils where urban trees are planted can slow runoff when compared to impermeable surface such as pavement.

	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	High	Increased evapotranspiration (ET) is one of the main effects of trees on the hydrologic cycle. Trees in urban areas will increase ET, which can be beneficial in wet or temperate areas as it will reduce the amount of runoff entering storm drains and can increase the water holding capacity of the soil by leaving it drier than it would be if trees were not present.
	Increase Infiltration and/or groundwater recharge	Medium	Trees in urban areas can have a moderate effect on infiltration and groundwater recharge.
	Increase soil water retention	Medium	Under some circumstances, trees in urban areas can increase soil water retention by facilitating greater rates of infiltration and enhancing groundwater recharge. The beneficial effect of urban trees on soil water retention needs to be balanced against the local increases in evapotranspiration that trees cause.
Reducing Pollution	Reduce pollutant sources	Medium	Trees in urban areas can contribute to reductions in water pollution by intercepting and retaining nutrients including nitrogen and phosphorus.
	Intercept pollution pathways	High	One of the key benefits of trees in urban areas is that they are able to intercept particulate air pollution. This can result in demonstrable improvements in air quality and the health of urban populations. Studies have been performed in China (Jin et al. 2014) and elsewhere to quantify the ability of trees in urban areas to remove particulate air pollution.
Soil Conservation	Reduce erosion and/or sediment delivery	Low	Because of their small "footprint" or zone of environmental influence, trees in urban areas have a limited ability to control erosion or to improve soils. While individual trees have a small zone of influence, they can help to stabilize soils and provide additional inputs of organic matter which improve soil quality.
	Improve soils	Low	
Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	High	Trees in urban areas have a high potential to create terrestrial habitat. Studies have shown that trees in urban areas can be biodiversity hotspots with more bird species than untreed areas (Ferenc et al. 2014).

Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	High	Trees in urban areas can contribute to reductions in peak temperature at ground level. Because trees have a higher albedo than many urban surfaces, they reflect instead of absorbing heat. The evapotranspiration from trees also contributes to local cooling.
	Absorb and/or retain CO2	High	Urban trees can be locally important for absorbing and retaining CO2. While individual trees do not absorb a significant amount of CO2, larger numbers of urban trees can have a relevant impact of the greenhouse gas balance of cities.

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Water Storage	Medium	Under some circumstances, urban trees can have a positive effect on water storage. They can also provide additional room in the soil for storing water as their root systems will draw up water which is transpired, leading to drier soils.
	Fish stocks and recruiting	None	
	Natural biomass production	Medium	As with any trees, trees in urban areas have a potential for natural biomass production. However, this biomass is unlikely to be harvested. Because trees in urban areas often require more pruning and maintenance than trees in forests, there may be some biomass generated for bioenergy production or other uses.
Regulatory and Maintenance	Biodiversity preservation	High	Trees in urban areas, especially larger and older trees, have high biodiversity benefits (Ferenc et al. 2014). Trees offer habitat that may not otherwise exist in urban areas. The effects of trees on biodiversity preservation are apparent for bird species in urban areas. There are probably also biodiversity benefits for insects and lichens.
	Climate change adaptation and mitigation	High	Trees in urban areas have a high climate change adaptation and mitigation potential. While individual trees do not sequester large amounts of carbon, when sequestration is summed across a city, the effect can be considerable. Trees in urban areas can also contribute to climate change mitigation as they can limit peak temperatures at ground level. Trees also reduce wind speed and have potential to moderate temperature by

			offering shade from sunlight and shield from cold winter breezes.
	Groundwater / aquifer recharge	Medium	Trees in urban areas can have a moderate effect on groundwater or aquifer recharge. The soils in close proximity to urban trees typically have higher infiltration rates than the impervious surfaces typical of urban environments. The greater infiltration and recharge capacity associated with trees in urban areas must be balanced against the increased evapotranspiration which will also be observed. This may be especially relevant in dry areas or where urban trees must be irrigated to survive.
	Flood risk reduction	Low	Trees in urban areas can contribute to flood risk reduction by drying out soils in their immediate vicinity. Evapotranspiration can lower water levels in close proximity to trees. These lower water levels and drier soils, in combination with higher infiltration capacity, can act as a water store in the urban landscape and reduce flood peaks. This effect is likely to be most apparent for summer storms and other precipitation in drier conditions instead of spring snowmelt.
	Erosion / sediment control	Low	Trees in urban areas can contribute to erosion and sediment control but the overall effect is likely to be minor because of their relatively small environmental footprint.
	Filtration of pollutants	High	Trees in urban areas have a high potential for filtration of pollutants, especially airborne particulates (Jin et al. 2014). This effect can be extremely important in polluted urban areas and megacities where air pollution can have negative effects on human health.
Cultural	Recreational opportunities	High	Trees in urban areas may create environment for recreation activities. Appearance of fauna associated with trees, e.g., birds, should be accounted for in recreational values.
	Aesthetic / cultural value	High	Trees in urban areas can have high aesthetic value. Trees can be an important element of urban planning and design and can greatly improve the attractiveness of urban environments.
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biological quality elements	None	Because of the great difference in spatial scales between the zone of environmental influence of urban trees and Water Framework Directive (WFD) waterbodies, it is hard to link the benefits observed in urban areas due to the presence of trees with changes in WFD waterbody status. This is not to deny the positive effects of urban trees on the urban environment but merely a recognition of the difficulties of linking very local scale measures to large scale responses.
	Improving status of physico-chemical quality elements	None	
	Improving status of hydromorphological quality elements	None	
	Improving chemical status and priority substances	None	
Achieve Good GW Status	Improved quantitative status	Low	Because trees in urban areas are often associated with improved infiltration capacity and greater retention of pollutants, they can have a positive effect on quantitative and chemical status of urban groundwater aquifers. While the effect of forest trees on urban groundwater status are undoubtedly real, they can be hard to demonstrate due to heterogeneity of groundwater aquifers, difficulties of sampling, and the small environmental footprint of individual trees.
	Improved chemical status	Low	
Prevent Deterioration	Prevent surface water status deterioration	Low	Urban trees can make a local contribution to prevention of deterioration in status of both surface waters and groundwaters. This effect may be difficult to detect at all but the most local of scales.
	Prevent groundwater status deterioration	Low	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Low	Urban trees can contribute to increasing the water storage capacity in urban environments and thereby play a role in co-ordinated measures to reduce flood risks. While the effect of individual trees on flood risk reduction will be minimal, the effects may be noticeable when summed across all the trees in an urban area.
Habitats and Birds Directives			
Protection of Important Habitats		High	As noted by Ferenc et al. (2014) and others, large and older trees in urban areas can provide important bird habitat and may also have beneficial effects for other species.

2020 Biodiversity Strategy		
Better protection for ecosystems and more use of Green Infrastructure	High	Trees are an important component of urban green infrastructure and help to naturalize urban ecosystems. Trees in urban areas provide multiple ecosystem services related to water retention, flood management, biodiversity enhancement as well as climate change adaptation through their localized cooling effects and mitigation through carbon sequestration.
More sustainable agriculture and forestry	None	
Better management of fish stocks	None	
Prevention of biodiversity loss	High	As noted by Ferenc et al. (2014) and others, large and older trees in urban areas can play an important role in maintaining or enhancing urban biodiversity by acting as important bird habitat.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	
Space required	The space required for urban trees will depend on their crown size and root network. While crown size can be managed through pruning, the root network of urban trees is potentially extensive and may cause damage to existing underground infrastructure, especially leaky sewers which trees may tap for water and nutrients.
Location	Urban trees are typically located in parks and along roadways. Jin et al (2014) report on the pollution prevention effects of trees in "urban canyons" where highrise buildings dominate the landscape.
Site and slope stability	
Soils and groundwater	
Pre-treatment requirements	
Synergies with Other Measures	Trees in urban areas have synergies with urban forests and other urban NWRM measures.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		
Investigations & Studies		
Capital Costs		The capital costs of trees will depend on the age at which they are planted, with older, larger trees being more expensive than younger, smaller trees.
Maintenance Costs		The costs of pruning and maintaining trees need to be considered when planning trees in urban areas as a natural water retention measure.
Additional Costs		In dry or drought prone areas, this measure may incur additional costs associated with irrigation.

X. Governance and Implementation

Requirement	Evidence

XI. Incentives supporting the financing of the NWRM

Type	Evidence

XII. References

Reference	Comments
Neary, Daniel G., George G. Ice, and C. Rhett Jackson. "Linkages between forest soils and water quality and quantity." Forest Ecology and Management258.10 (2009): 2269-2281.	Good general reference on forest water issues
Dwyer, John F., et al. "Assessing the benefits and costs of the urban forest."Journal of Arboriculture 18 (1992): 227-227.	Older but useful review of trees in the urban environment

Pataki, Diane E., et al. "Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions." Frontiers in Ecology and the Environment 9.1 (2011): 27-36.	Important recent article on quantifiable benefits of urban forestry on water quality and runoff
Jin, S., Guo, J., Wheeler, S., Kan, L., & Che, S. (2014). Evaluation of impacts of trees on PM 2.5 dispersion in urban streets. Atmospheric Environment, 99, 277-287.	Article presenting evidence from Shanghai as to the benefits of urban trees on reducing air pollution
Ferenc, M., Sedláček, O., & Fuchs, R. (2014). How to improve urban greenspace for woodland birds: site and local-scale determinants of bird species richness. Urban Ecosystems, 17(2), 625-640.	Evidence for the biodiversity benefits of urban trees
H. Akbari , M. Pomerantz and H. Taha. 2001. Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas. Solar Energy 70(3): 295–310	Provides examples of microclimate-related benefits of trees in urban environment and potential establishment costs
Per Bolund, Sven Hunhammar. 1999. Ecosystem services in urban areas. Ecological Economics 29: 293–301	Overview of ecosystem services in urban areas, including those delivered by trees