USC Urban Trees Initiative

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Research Brief: Quantifying How Tree Species in Los Angeles Impact Air Quality

PUBLIC EXCHANGE · CARBON CENSUS at USC · USC Dornsife Spatial Sciences Institute · USC Architecture · USC University Relations

The Challenge

Trees provide shade, sequester atmospheric carbon dioxide, and remove air pollutants through deposition. However, some trees emit volatile organic compounds (VOCs) which can react to form particulate matter (PM) and ozone (O_3). Quantifying the role of urban trees as both sources and sinks of air pollution remains a challenge.

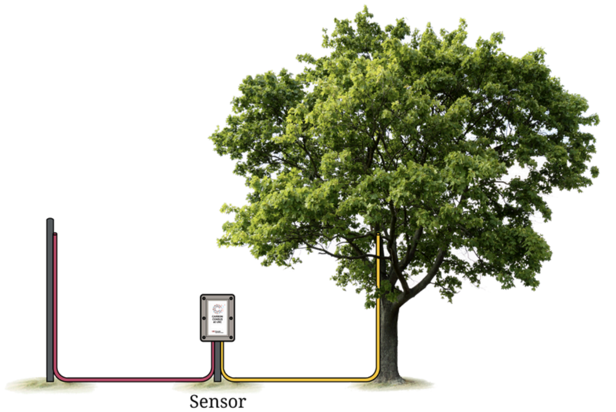

Figure 1: The sensor box alternatively draws air from the tree canopy and from the ambient environment providing a read on if and how much the tree canopy is impacting PM concentration.

The Research

The USC Urban Trees Initiative (USC Trees) teamed up with the City of Los Angeles Office of Forest Management, L.A. City Bureau of Sanitation and Environment, and Amigos Nursery in South L.A. to make more evidence-based decisions regarding trees and air pollution. Led by Will Berelson from USC's Dornsife Earth Sciences Department, the team set out to interrogate different tree species common in L.A. To perform experiments, they built a unique sensor box (see Figure 1) and compared findings to the academic literature.

The Key Findings

1. Pollution removal is among the many benefits of urban trees, yet this process is nuanced and not well-quantified for L.A. trees. **From field measurements on different tree species, we have verified that PM deposition rates on various tree species observed in Amigos Nursery generally agrees with the values derived from literature-based models (See Table 1)**.

Species of Interest	Common Name	Literature Model Modeled PM2.5 removal rate (g/tree/day)	Amigos Nursery Observed PM2.5 removal rate (g/tree/day)
Cedrus deodara	Deodar Cedar	0.55	0.03
Ficus rubiginosa	Rustyleaf Fig	0.53	0
Jacaranda mimosifolia	Jacaranda	0.17	0.1
Quercus agrifolia	Coast Live Oak	0.17	0.09
Lophostemon confertus	Brisbane Box	0.06	0.25
Afrocarpus gracilior	African Fern Pine	0.05	0.19
Bauhinia variegata	Purple Orchid	0.04	0
Geijera parviflora	Australian Willow	0.03	0.13
Searsia lancea	African Sumac	0.01	0.2
Lagerstroemia indica	Crape Myrtle	0.01	0.05

Table 1: Comparison of observed PM uptake and literature-based model uptake rates for 10 tree species. The more green the boxed value, the more PM uptake.

2. **Uptake of PM by trees occurs when the air is calm, which is generally in the nighttime, which is also the time when PM concentrations are highest.** Particulate Matter in Los Angeles is at its highest during the evening of the 4th of July. We placed sensors in trees and sensors not in trees to capture the difference in PM concentrations. We see that tree canopies can reduce PM by >20 μg/m3 compared to the ambient air. We also see that trees are more effective at taking up PM during the nighttime—this is because winds are calmer and calm air allows PM to settle onto leaves. When the wind blows, there is more turbulence and fine particles remain suspended in the air.

3. **Ranking trees by species that consume more pollutants than they contribute to may be useful for practitioners in selecting tree species.** A scorecard, as the name implies, provides a ranking of tree species and how they perform in terms of net PM and ozone uptake. The scorecard below, is based on 42 species of trees using literature and model-based estimates of tree performance. Trees are ranked in terms of net impact. As seen in Figure 2, there are many more trees that are effective as net removers of PM (green) than there are trees that add PM (red). However, if L.A. has too many of the trees in red, that could be problematic for ambient concentrations.

PM

Latin Name	Net PM 2.5 (g/tree/day)
Fraxinus uhdei	-0.552
Pinus pinea	-0.525
Cedrus deodara	-0.465
Pinus halepensis	-0.442
Ulmus americana	-0.401
Cinnamomum camphora	-0.356
Ulmus parvifolia	-0.255
Pinus canariensis	-0.175
Ligustrum lucidum	-0.175
Jacaranda mimosifolia	-0.170
Platanus racemosa	-0.141
Schinus molle	-0.140
Quercus lobata	-0.119
Olea europaea	-0.118
Pittosporum tobira	-0.115
Juniperus chinensis	-0.112
Pyrus kawakamii	-0.106
Pittosporum undulatum	-0.098
Cupressus sempervirens	-0.082
Pinus radiata	-0.077
Nerium oleander	-0.055
Afrocarpus gracilior	-0.049
Callistemon citrinus	-0.041
Persea americana	-0.022
Prunus armeniaca	-0.021
Prunus persica	-0.018
Lagerstroemia indica	-0.010
Quercus virginiana	-0.010
Cercis canadensis	-0.008
Xylosma congestum	-0.004
Ginkgo biloba	0.001
Platanus occidentalis	0.003
Pistacia	0.009
Schinus terebinthefolia	0.009
Robinia pseudoacacia	0.011
Vachellia farnesiana	0.014
Acer saccharinum	0.024
Quercus agrifolia	0.055
Magnolia grandiflora	0.124
Cupaniopsis anacardioides	0.156
Taxodium mucronatum	0.216
Liquidambar styraciflua	2.106

O_3

Latin Name	Net O3 (g/tree/day)
Fraxinus uhdei	-23.808
Pinus pinea	-23.157
Cedrus deodara	-21.574
Pinus halepensis	-19.721
Ulmus americana	-17.279
Cinnamomum camphora	-15.335
Acer saccharinum	-15.241
Pinus canariensis	-11.565
Ulmus parvifolia	-10.976
Schinus molle	-8.750
Ligustrum lucidum	-7.551
Jacaranda mimosifolia	-7.333
Olea europaea	-5.306
Juniperus chinensis	-5.252
Pittosporum tobira	-4.971
Pyrus kawakamii	-4.570
Pittosporum undulatum	-4.210
Pinus radiata	-3.771
Cupressus sempervirens	-3.577
Nerium oleander	-2.368
Afrocarpus gracilior	-2.106
Persea americana	-0.935
Prunus armeniaca	-0.912
Prunus persica	-0.807
Lagerstroemia indica	-0.449
Cercis canadensis	-0.339
Magnolia grandiflora	-0.226
Ginkgo biloba	-0.167
Vachellia farnesiana	-0.076
Schinus terebinthefolia	0.092
Pistacia	0.155
Xylosma congestum	0.863
Taxodium mucronatum	2.724
Quercus lobata	3.082
Callistemon citrinus	29.903
Quercus virginiana	33.779
Platanus racemosa	36.820
Robinia pseudoacacia	66.385
Platanus occidentalis	95.649
Quercus agrifolia	105.215
Cupaniopsis anacardioides	158.454
Liquidambar styraciflua	185.551

Figure 2: Lists of 42 tree specied ranked in terms of their NET impact on air quality. Negative values (green) are net uptake, positive values (red) are producing pollutants.

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References

Berelson, W., N. Rollins, J. Kim, E. Johnson, E. Margulies, N. Casas, B. MacDonald and J. Wilson (2023) A protable sensor for the determination of tree canopy air quality. Environmental Science:Atmospheres. DOI: 10.1039/d3ea00057e

Vannucci, P., A. Kianmehr, C. C. Pawlak, C. L. Faiola, J. P. Wilson and W. M. Berelson (2024) Quantifying the current and future role of urban tree species in modulating summertime air pollution in Los Angeles, CA. In Revision, ES&T: Air

Research Methods

Tree PM uptake rates were measured at Amigos Nursery during the summer of 2022 using a methodology described by Berelson et al. 2023. The literature-based model data for PM and ozone production and uptake is based on model calculations and parameters described in Vannucci et al. 2024.

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For More Information

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