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Investigation of the effects of tree species on air quality using i-Tree software: A case study in California

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Abstract The USDA Forest Service has developed a unique software and tree modelling suite called i-Tree. Several of its instruments are capable of exploring the benefits of trees and forests for pollution mitigation, reduction of storm water runoff, carbon sequestration and storage. However, the system remains underutilized for investigating the effects of trees on air quality. In this study, counties in California (CA), United States, were selected using the i-Tree Landscape tool. Next, several characteristics including land cover details, forest details, population, air quality, carbon sequestration capacity, and air pollution removal capacity, were investigated. When considering the air quality situation in these counties, O_3 and $PM_{2.5}$ are the primary pollutants. The planting prioritization map of California was created based on population density, tree cover, plantable space, average $PM_{2.5}$ and O_3 concentration values, and the counties with the highest planting priority were selected using i-Tree Planting tool. Using this instrument, a case study on the modelling of the removal performances of these air pollutants by multiple new species (Turkey oak, Siberian elm, European hackberry, European white elm, common ash, European silver birch, velvet ash, black alder, bigleaf linden) in priority areas was conducted. The most effective modelled tree species in the area was found to be Turkey oak for its effects in improving air quality in general and O_3 in particular. When compared to the effects of modelled trees, the effects of the existing public trees in California were determined to have a comparatively minor impact.

Keywords: i-Tree, forests, trees, air pollution, air pollution removal, planting.

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Introduction

The majority of environmental threats to human health is concentrated in urban areas (Bolund & Hunhammar 1999). In urban environments, human activities causing air pollution emissions occur much more frequently than in rural areas, leading to a variety of adverse health outcomes, including premature mortality and morbidity from cardiovascular and respiratory causes (Brunekreef & Holgate 2002, Heinrich & Wichmann 2004, WHO 2006, Rückerl et al. 2011).

Fine particulate matter (PM2.5) pollution is regarded as one of the world's most important health concerns (Liacos et al. 2012, Han et al. 2017, Li et al. 2019, Shen et al. 2019). Previous studies on $PM_{2.5}$ have mostly focused on source apportionment, monitoring, and modelling (Li et al. 2010, Ma et al. 2014). However, cutting pollution at its source is not enough to substantially bring down $PM_{2.5}$ levels. New approaches need to be developed to reduce $PM_{2.5}$ levels.

The microstructure of the leaves is closely correlated with their removal ability (Zhao et al. 2019), and dry deposition on the branches, stems, and leaves of urban vegetation has been proposed as an efficient and cost-effective long-term method of removing particulate matter of all sizes (Hirabayashi & Nowak 2016, Kroeger et al. 2018).

Several studies have discovered and documented the services that trees in urban ecosystems provide, such as cleaning the air through dry deposition (Nowak 2000, Nowak et al. 2006); controlling temperatures (through shading and evaporation) to reduce the urban heat island (Yang et al. 2005, Frosini et al. 2024), and storing carbon to help fight climate change while selecting species with low BVOC emissions can enhance these benefits (Kofel et al. 2024, Ferreira et al. 2024). On the other hand, some other studies have found adverse effects. For example, Owen et al. (2003) found that trees release Volatile Organic Compounds (VOCs), and Tiwary and Kumar (2014) found that heavily planted plantations cause local air pollution to rise. In a simulation of how trees and shrubs affect particle dispersion at the street scale in Strasbourg, a street canyon with heavily planted trees showed an increase in particle concentration (Wania et al. 2012). These mixed results indicate that there are knowledge gaps in our mechanistic understanding of the physical and chemical processes of the vegetation-atmosphere environments over urban areas. Cherlin et al. (2015) suggest that this knowledge gap is mostly due to a paucity of studies that use numerical models to characterize the physical and chemical interactions between the tree species and the atmosphere in urban environments.

For continental-scale studies, Petroff and Zhang (2010) developed a dry deposition model to predict how much particulate matter falls to the ground under real-world conditions. Jayasooriya et al. (2017) and Jeanjean et al. (2017) modelled and estimated the deposition rates of different tree species to assess the degree at which green roofs and green walls improve air quality in cities and reduce energy costs for commercial and residential buildings on a block-by-block level. Nowak et al. (2013) estimated dry deposition by using the Environmental Benefits Mapping and Analysis Program (BenMAP) models to estimate how much pollution urban plants remove and how much money that is worth in ten towns and regions across the United States. Annual $PM_{2.5}$ removal by trees ranged from 4.7 tonnes in Syracuse to 64.5 tonnes in Atlanta, with values ranging from \$1.1 million in Syracuse to \$60.1 million in New York City. More studies were conducted on a national level in the United States and Canada (Nowak et al. 2008, Nowak et al. 2014, Hirabayashi & Nowak 2016, Nowak et al. 2018).

The i-Tree software suite, developed by the U.S. Department of Agriculture (USDA) Forest Service, offers a range of tools designed to assess and value urban forest resources, understand forest risks, and develop sustainable forest management plans to enhance environmental quality and human health Applicable to both urban and rural settings, these tools evaluate individual trees and forest ecosystems. With a vision to improve forest and human health globally, i-Tree leverages user-friendly technology to foster resilience and effective forest management. Although the scientific foundation and models underlying i-Tree have been in development since the mid-1990s, the software suite was officially launched in 2006 as a framework for scientific analysis and decision-making (Nowak 2024).

I-Tree Eco has become a vital tool for urban management and planning, providing a detailed assessment of ecological services offered by trees. The software uses comprehensive tree survey data - including species, diameter at breast height, and tree height - to estimate multiple ecological functions, such as pollution removal, carbon storage, annual carbon sequestration, and biogenic volatile organic compound (BVOC) emissions. These data form a robust foundation for evaluating trees' ecological functions, enhancing the reliability of assessment outcomes. i-Tree Eco can accurately estimate various indicators at the individual tree level and has been applied in cities worldwide, including multiple cities in China, demonstrating its versatility across diverse contexts (Han et al. 2024, Sjöman, et al. 2024).

Notable examples of its application include evaluating urban tree cover and land cover changes in Edirne, Türkiye (Malkoç 2024) and assessing the impact of green cover changes on air quality around Ulu Cami in Osmangazi, Bursa (Bingöl & Arıcak 2024). Additionally, the software has been used in Vietnam's Hung Yen province to quantify the environmental services and economic value of urban tree species in public green spaces (Selmi et al. 2016, Bottalico et al. 2017, Ngoc et al. 2024) have used the I-Tree Eco model, which uses the well-known Urban Forest Effects (UFORE) model, to determine the annual removal rate of $PM_{2.5}$ by different types of urban vegetation. I-Tree Eco also aids tree planting efforts by guiding species selection through an integrated Pollution and Carbon Reduction Index (PCRI) (Han et al. 2024), prioritizing trees with high pollution mitigation and carbon reduction capabilities. With its ability to provide quantitative maps of urban forests, numerical measurements of ecological services, and economic valuations of benefits, i-Tree Eco is an invaluable tool for sustainable urban forest management (Sjöman et al. 2024). Moreover, it offers insights into potential challenges faced by urban tree managers, as highlighted by studies like Nowak (2021), which explore its application and usability.

Despite widespread application of the i-Tree software suite (www.itreetools.org) in various regions worldwide, the potential ecosystem benefits of urban green spaces in California, particularly concerning air pollution removal, remain underexplored. This study utilizes i-Tree Eco to evaluate the role of urban trees in mitigating air pollution in a specific region of California, offering insights into their ecological and environmental contributions.

Materials and Methods

Study area

Because of its sizable population and wealth of manufacturing facilities, California, USA has been chosen as a research site. State of California; one of the 50 states that make up the USA. Oregon is to the north, Nevada and Arizona are to the east, Baja California is to the south, and the Pacific Ocean is to the west of California. California is a land of amazing physical differences, from its rainy northern coast to the arid Colorado Desert in the south, and from its Mediterranean-like middle and southern littoral to the volcanic plateau in the extreme northeast.

Air pollution remains a significant public health issue. A number of air pollutants resulting from a variety of industrial processes negatively influence the health of Californians. Monitoring of the air indicates that over ninety percent of Californians are exposed to harmful levels of one or more air pollutants at some point during the year. The health of Californians is negatively impacted by a variety of air pollutants produced by industrial processes (Jerrett et al. 2013). Fine particulate matter and ozone are two of the most dangerous pollutants from the standpoint of public health. Sources of PM$_{2.5}$ include direct emissions from the combustion of petroleum, diesel, and other fuels, as well as the combustion of wood. PM$_{2.5}$ is also produced by the chemical reactions of precursors emitted from combustion sources, such as automobiles, in the atmosphere (De Nevers 2010). PM$_{2.5}$ includes diesel engine pollution, which is of particular concern due to its adverse health effects. Ozone is one of the principal components of smog and is produced in the atmosphere through complex reactions with compounds directly emitted by motor vehicles and other combustion sources (California Air Resources Board 2023). Consequently, it is crucial to take precautions against this air pollution issue in the region.

Landscape and prioritization map

The i-Tree landscape tool is utilized to collect data on population density, tree species, canopy and plantable space, air quality, CO$_2$ sequestration capacity, avoided discharge, and air pollution removal performances of the existing trees. In addition, a program can be used to generate a planting prioritization map using existing data of the selected area and a user-defined scenario. This tool used the 2011 NLCD (National Land Cover Data) that was already in the system.

The following steps and procedures to generate the planting prioritization map of California were followed:

1. Initially, the counties of California were selected using Google Earth map. The map of selected areas is shown in Figure 1. The cyan lines represent the counties in the California region.

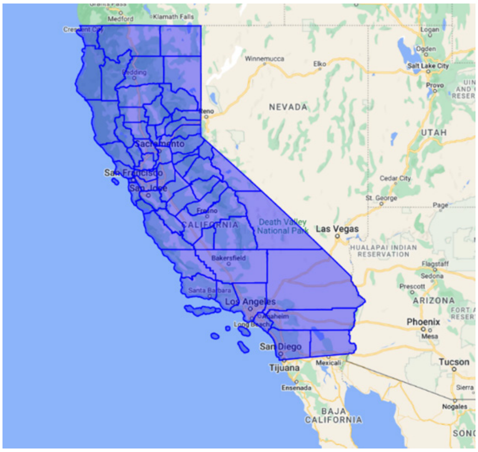

Figure 1 The map of selected counties of California, USA.

2. The canopy, impervious, and plantable space data were collected and displayed on the map of the selected area (Figure 2).
3. The forest types that were already extant in the area were tabulated (Table S1 in Supplementary Materials).
4. The population was surveyed for information. (Table S2 in Supplementary Materials).
5. The area's air quality was displayed on the map (Figure 4 and Table S3 in Supplementary Materials).
6. The benefits of trees, including carbon sequestration and air pollution abatement, were identified and displayed as tables (Table S4 in Supplementary Materials).
7. The area's priority map was constructed based on a custom scenario (low tree cover per capita, high population density, high plantable space, high average PM$_{2.5}$ concentration ($\mu g / m^3$), and high average O$_3$ concentration (ppb) in which all elements were assumed to be evenly distributed.
8. On the map, the priority areas were displayed. The areas with a score greater than 70 (colour scale: 🟧) were identified as priority areas (Figure 3).

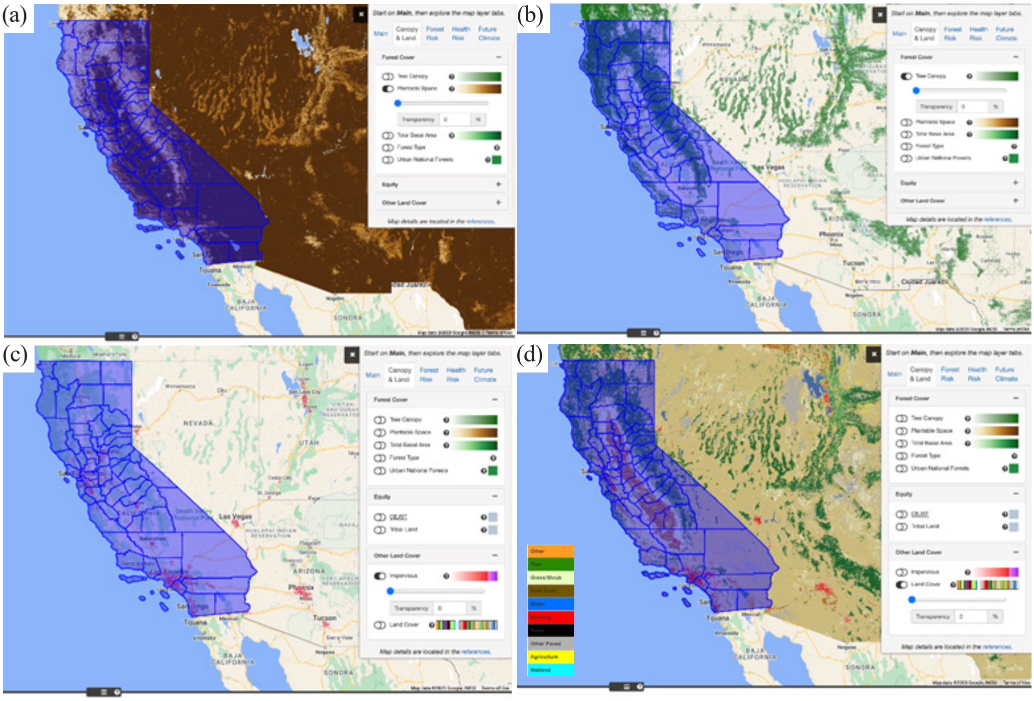

Figure 2 (a) Plantable space, (b) tree canopy, (c) impervious and (d) land cover of the selected area.

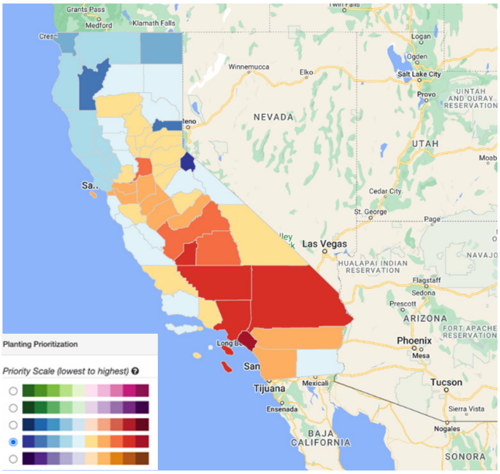

Figure 3 Planting prioritization map of the selected area.

Model development

The i-Tree planting instrument was used to predict the benefits of various tree species used for air purification but not present in priority areas. Table 1 lists the selected priority areas, the percentage of forest categories present in the area, the tree cover area and plantable space.

The nine plant species used for prediction were: Turkey oak (*Quercus laevis*), Siberian elm (*Ulmus pumila*), European hackberry (*Celtis australis*), European white elm (*Ulmus laevis*), common ash (*Fraxinus excelsior* ssp. *excelsior*), European silver birch (*Betula pendula* ssp. *pendula*), velvet ash (*Fraxinus velutina*), black alder (*Alnus glutinosa* ssp. *glutinosa*), bigleaf linden (*Tilia platyphyllos*).

Tree covered areas were used to establish the quantity of each species. The number was calculated based on the fact that there are 1,500 trees per hectare in the area, upon which the assumption regarding the covered area was made. In other words, the number of model trees was determined with respect to the present trees found in the area. There are nine species to be modelled, so the total quantity of model trees for each species was divided as 14% of Turkey oak, 12% Siberian elm, 12% of European hackberry, 10% of European white elm, 10% of common ash, 10% of European silver birch, 12% of velvet ash, 10% of black alder, 10% of bigleaf linden. Table 2 displays the quantity of trees entered into the model for each priority area. Their capacity for carbon sequestration and removal of air pollution was predicted. Several parameter assumptions were incorporated into the model, including the electricity emissions factor (252.4), the fuel emissions factor (52), the lifetime (40), and the tree mortality (70).

Table 1 Priority areas, forest types, covered area, and plantable area.

Priority areas	Forest types (%)	Tree covered area (ha)	Plantable area (ha)
San Bernardino	California mixed conifer (43.59%) fir/spruce/mountain hemlock (0.01%) lodgepole pine (4.01%) other western hardwoods (1.29%) pinyon/juniper (19.23%) ponderosa pine (6.09%) western oak (25.78%)	32,043.4	5,098,138.6
Kern	California mixed conifer (11.95%) fir/spruce/mountain hemlock (0.02%) other western hardwoods (0.01%) pinyon/juniper (6.95%) ponderosa pine (7.30%) redwood (0.01%) western oak (73.74%)	102,737.0	1,968,172.1
Sacramento	n/a*	6,685.6	207,945.5
Fresno	aspen/birch (0.01%) California mixed conifer (27.45%) fir/spruce/mountain hemlock (8.50%) lodgepole pine (31.17%) other western softwood (2.39%) pinyon/juniper (1.86%) ponderosa pine (3.85%) redwood (0.04%) western oak (24.44%) western white pine (0.28%)	223,734.2	1,287,210.4
Kings	n/a*	826.3	350,510.3
San Francisco	ponderosa pine (10.00%) western oak (90.00%)	1,026.6	3,614.8
Orange	western oak (100.00%)	3,690.2	136,893.0
Tulare	California mixed conifer (31.38%) fir/spruce/mountain hemlock (4.80%) lodgepole pine (17.46%) other western softwood (0.87%) pinyon/juniper (7.06%) ponderosa pine (9.93%) redwood (0.08%) western oak (28.30%) western white pine (0.12%)	247,921.1	988,194.2
Los Angeles	California mixed conifer (22.47%) lodgepole pine (3.72%) other western hardwoods (0.02%) pinyon/juniper (3.06%) ponderosa pine (15.06%) tanoak/laurel (5.19%) western oak (50.50%)	44,451.0	837,371.5

Note: * not available

Results

Landscape features and planting prioritization area

Figure 2 depicts the land use distribution, consisting of tree canopy plantable space, impervious areas, and land cover. The area has a high potential for planting new species with huge plantable areas, while the amount of impervious area is very low. Figure 3 depicts the planting prioritization area. Shown on the map are low prioritization areas denoted by light color, in the north, and high prioritization areas denoted by dark color, located in the south. San Bernardino, Kern, Sacramento, Fresno, Kings, San Francisco, Orange, Tulare, and Los Angeles were determined as priority areas (Fig. 3).

Using the i-Tree landscape tool, the area's total tree canopy is determined to be 7,207,080.1 hectare, its total impervious surface is 950,353.7 ha, and its total plantable space is 32,189,267.6 ha. The total tree types found in the area were identified by i-Tree Landscape tool as alder/maple (0.12%), aspen/birch (0.08%), California mixed conifer (37.34%), Douglas-fir (3.11%), fir/spruce/mountain hemlock (7.42%), lodgepole pine (5.15%), other western hardwoods (0.34%), other western softwood (0.97%),

Table 2 The number of plant species entered into the model for each priority area.

Plant Species	%	San Bernardino	Kern	Sacramento	Fresno	Kings	San Francisco	Orange	Tulare	Los Angeles
Turkey oak	14	6729114	21574770	1403976	46984182	173523	215586	774942	52063431	9334710
Siberian elm	12	5767812	18492660	1203408	40272156	148734	184788	664236	44625798	8001180
European hackberry	12	5767812	18492660	1203408	40272156	148734	184788	664236	44625798	8001180
European white elm	10	4806510	15410550	1002840	33560130	123945	153990	553530	37188165	6667650
Common ash	10	4806510	15410550	1002840	33560130	123945	153990	553530	37188165	6667650
European silver birch	10	4806510	15410550	1002840	33560130	123945	153990	553530	37188165	6667650
Velvet ash	12	5767812	18492660	1203408	40272156	148734	184788	664236	44625798	8001180
Black alder	10	4806510	15410550	1002840	33560130	123945	153990	553530	37188165	6667650
Bigleaf linden	10	4806510	15410550	1002840	33560130	123945	153990	553530	37188165	6667650
Total		48065100	154105500	10028400	335601300	1239450	1539900	5535300	371881650	66676500

pinyon/juniper (5.75%), ponderosa pine (10.39%), redwood (2.29%), tanoak/laurel (5.62%), western oak (21.17%), western white pine (0.25%).

Air quality

Figure 4 displays the air quality spatial distribution of average and maximum $PM_{2.5}$ and O_3 concentrations. Average and maximum $PM_{2.5}$ and O_3 concentration values in the area are plotted in Figure 5. Maximum ozone and average and maximum $PM_{2.5}$ values indicates that selected area has a poor air quality and especially in the priority areas such as Tulare, San Bernardino, Sacramento, Kern air quality were detected poor with respect to both $PM_{2.5}$ and O_3 pollution with respect to limit values established by USEPA (United States Environmental Protection Agency). The limit of O_3 (70 ppb) represents the annual fourth-highest daily maximum 8-hour concentration, and the limit of $PM_{2.5}$ (35 µg/m³) represents the 98th percentile 24-hour concentration (USEPA 2023).

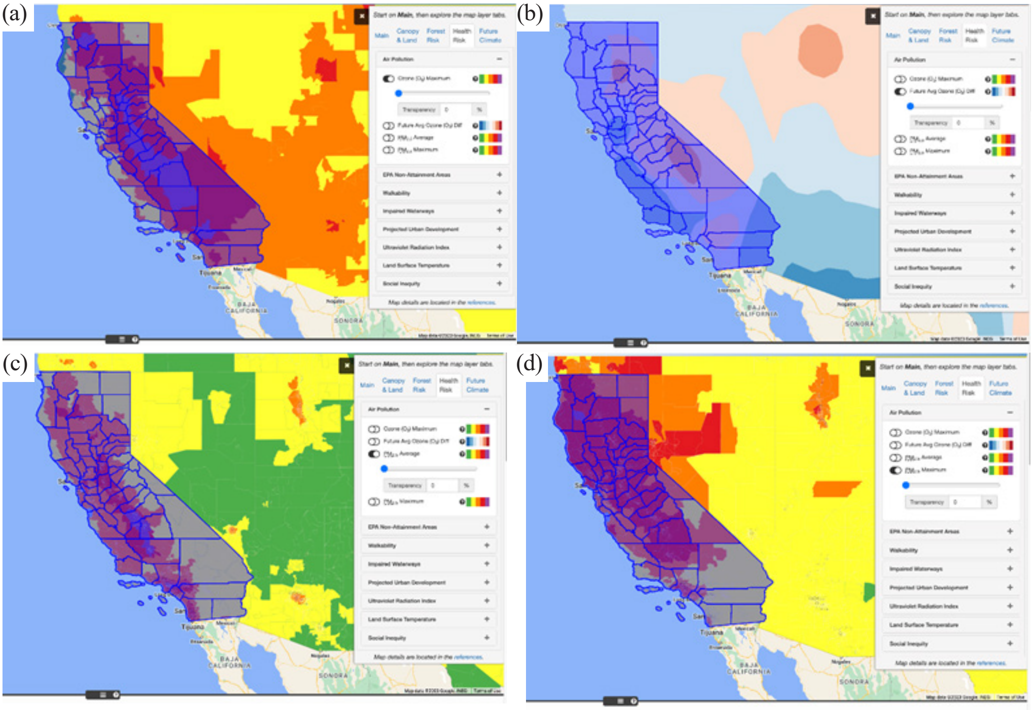

Figure 4 (a) Ozone (O3) maximum (ppb), (b) future average O_3 difference, (c) PM2.5 average (µg /m³) and (d) $PM_{2.5}$ maximum (µg /m³) of the selected area (the minimum color scale begins with green and dark blue).

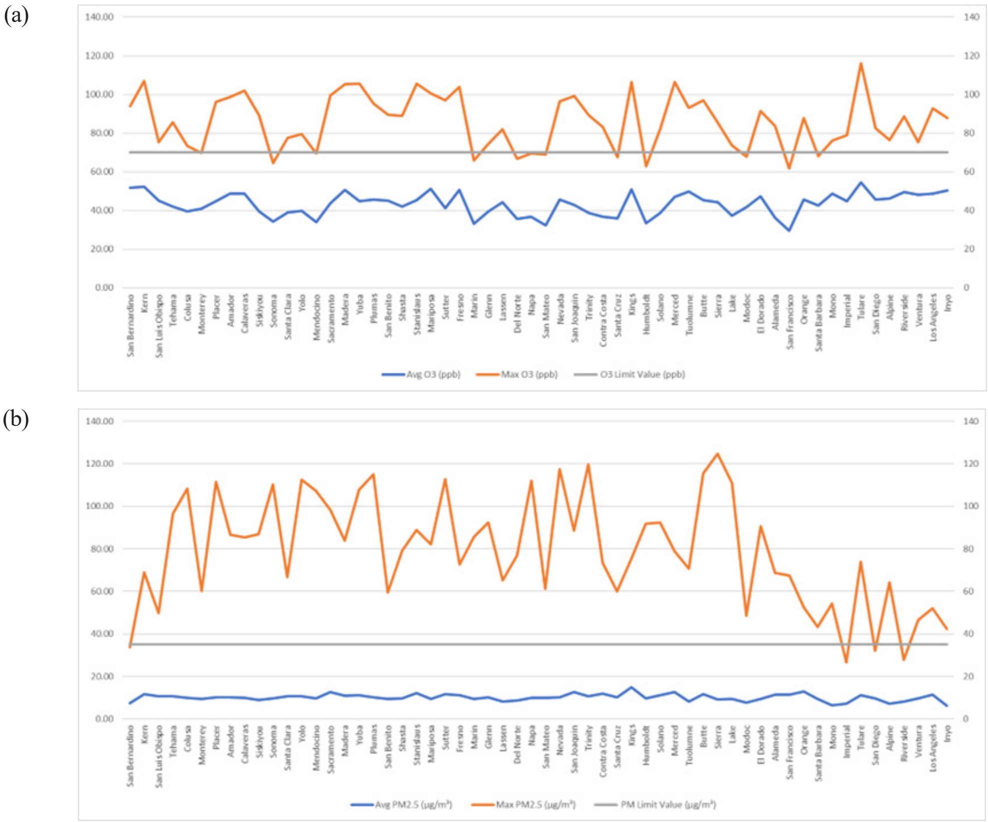

Figure 5 (a) Average and Maximum O_3 (ppb) concentrations and (b) Average and Maximum $PM_{2.5}$ (µg /m^3) concentrations of the selected area.

Air pollution removal and CO_2 sequestration capacity

The i-Tree landscape utility provides values for the area's CO_2 sequestration capacity and air pollution removal capacity. This analysis determined the area's total CO_2 sequestration capacity to be 60,403,526.5 tons per year. In accordance the total pollutant removal capacity of the selected area, the existing trees in the region have demonstrated superior O_3 and NO_2 removal (Fig. 6). In addition, Figure 7 displays the air pollution removal and CO_2 sequestration capacity of priority areas. The majority of counties identified as priority areas show little support for CO_2 sequestration of the total area and air pollution removal, including NO_2, SO_2, and $PM_{2.5}$, with the exception of O_3 removal.

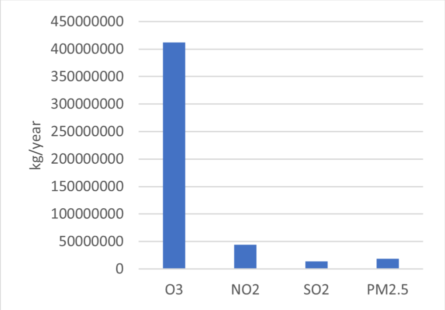

Figure 6 Total pollutant removal capacity of the selected area.

Model results

I-Tree planting tool gives the information about specified plants effects on air pollutants removal and CO_2 sequestration capacity. The results of this model are given in Table S5 in Supplementary Materials. Turkey oak tree has the most significant effect on CO_2 sequestration and air pollutants removal for all priority areas while bigleaf linden tree has the lowest effect on air pollution removal. The amounts given in Table S5 represent the overall results with respect to the whole lifetime of the project. Therefore, trees' total performance was determined by considering 40 years of lifetime. In Figure 7 air pollution removal rates and CO_2 sequestration capacities of modelled tree species (Turkey oak, Siberian elm, European hackberry, European white elm, common ash, European silver birch, velvet ash, black alder, bigleaf linden) were given as kg/year and ton/year. The most effective species for removing O_3 pollution and the other pollutants is the Turkey oak (Fig. 8). All of the trees selected for modelling exhibit improved performance in terms of the removal of O_3 and NO_2. When the potential of trees to store CO_2 was taken into consideration, the Turkey oak and the Siberian elm demonstrated superior performance.

In Figure 9, the CO_2 sequestration capacity and total air pollutant removal rates of models are presented in tons/year and kilograms/year for each priority area, also, the capacity of the modelled tree species to remove O_3 and NO_2 from the air in Tulare city has reached its maximum level. The rates of O_3 removal in Kern and Fresno cities are likewise much higher than the state average. However, in comparison to these models, clearance rates for SO_2 and $PM_{2.5}$ are not nearly as high in any of the priority locations. Sacramento, Kings, San Francisco, and Orange are the four cities that do not profit from the trees as much as they could. The number of trees that were entered into the model is the primary factor that determines why these rates were found.

When the advantages of the area's tree cover (Fig. 7) and those of the modelled trees (Fig. 9) are compared, although the tree species already present in the area make a considerable contribution to the removal of air pollutants, particularly ozone, the results of the model for the chosen tree species indicated a greater overall CO_2 sequestration capacity (seven times) and air pollution removal rate (three and a half times) than the tree cover that was already present in the area. This is an encouraging finding, and the environmental advantages that trees provide can be improved with the assistance of the tree species that are being supplied. According to a previous study that was conducted in China, increasing the amount of urban vegetation cover would have a beneficial effect on air quality because it would remove air pollutants; more specifically, growing new varieties of plants in selected places would result in the greatest potential for removal (Wu et al. 2019).

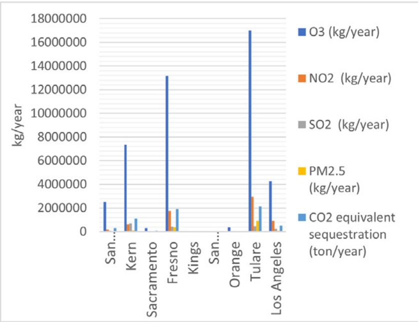

Figure 7 Air pollutants removal and CO_2 sequestration capacity of priority area.

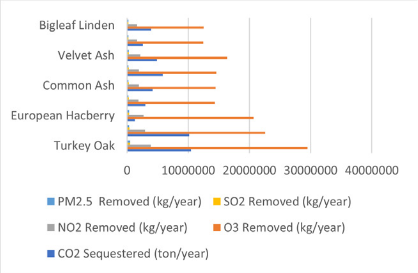

Figure 8 Total air pollution removal rates and CO_2 sequestration capacities with respect to modelled tree species.

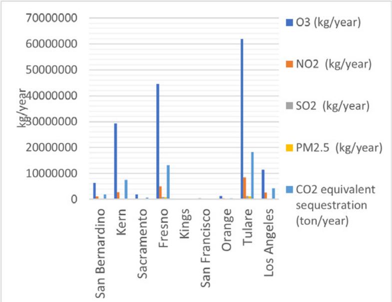

Figure 9 Total air pollutants removal and CO_2 sequestration capacity of model with respect to priority areas.

Discussion

The findings of this study emphasize the vital role of urban trees in mitigating air pollution, with ozone (O_3) removal standing out as the most significant among the pollutants investigated. The high efficiency of O_3 removal can be attributed to the elevated deposition velocities and local urban concentrations of this pollutant, as noted in previous studies (Nowak et al. 2006, 2014). Turkey oak, in particular, demonstrated exceptional performance, making it a valuable species for urban greening initiatives aimed at improving air quality. These results align with similar studies, such as those in France, which identified European beech and English oak as effective air-purifying species due to their large leaf surface areas and pollutant interception capacities (Selmi et al. 2016).

Tools such as i-Tree Landscape and i-Tree Planting allowed for the identification of priority planting areas based on comprehensive factors like population density, plantable space, and air pollutant concentrations. This integrative approach is particularly valuable in urban planning contexts where multiple competing priorities must be balanced.

The modeling results, which demonstrated the superior air quality benefits of Turkey oak, Siberian elm, and European hackberry, were consistent with findings from other studies. For instance, Mediterranean hackberry (*Celtis australis*), Norway maple (*Acer platanoides*), and littleleaf linden (*Tilia cordata*) have been identified in Europe as highly effective species for reducing air pollution, particularly particulate matter and ozone (Bressa 2016). Moreover, the reduction rate of airborne ultrafine particles (less than one micrometre in size) by the yew tree, the elder tree, and the silver birch were calculated to be 71%, 70.5%, and 79%, respectively (Wang et al. 2019). The study also reinforces the importance of prioritizing tree species with favorable leaf morphologies and low biogenic volatile organic compound (BVOC) emissions, as highlighted by Kofel et al. (2024).

Despite its robust methodology, the study has limitations that warrant consideration. One key limitation is the inherent reliance on modeling tools, which, while powerful, simplify complex real-world dynamics. Local microclimatic variations, seasonal effects, and interactions between trees and pollutants were not fully captured, potentially influencing the accuracy of the modeled outcomes.

Additionally, while Turkey oak showed excellent performance in reducing O_3, its BVOC emissions were not accounted for. High-emission species like *Quercus robur*, known to release isoprene and other compounds that contribute to secondary pollutant formation, present trade-offs that must be weighed in future planning (Kofel et al. 2024). This highlights the need to prioritize tree species with both high pollutant removal capacities and low BVOC emissions.

The geographical focus on select counties in California limits the generalizability of the findings. Urban forestry strategies must be tailored to specific local conditions, including climate, existing vegetation, and socio-economic factors, as demonstrated by studies conducted in diverse regions such as Brazil (Castelhano & Pinto 2024), Vietnam (Ngoc et al. 2024), and Korea (Hintural et al. 2024).

Finally, the study focused predominantly on tree planting and did not explore other complementary urban greening strategies, such as integrating shrubs or mangrove preservation, which have been shown to significantly enhance pollutant removal in urban settings (Zhao et al. 2023, Castelhano & Pinto 2024).

This study highlights the potential of urban trees as powerful tools for improving air quality and mitigating climate change. However, strategic planning is essential to maximize these benefits. Future research should address the identified limitations by incorporating a wider range of species that not only excel in pollutant removal but also exhibit low BVOC emissions, drought tolerance, and adaptability to urban conditions. Additionally, integrating localized data - such as environmental, climatic, and socio-economic variables - would refine models and enhance their applicability to specific regions. Exploring complementary strategies, such as assessing the combined effects of trees, shrubs, and other vegetation types on air quality and ecosystem services, could further strengthen urban greening efforts. Longitudinal studies that monitor the real-world performance of planted species over time would provide valuable insights into their effectiveness, ensuring that future urban forestry strategies are both evidence-based and impactful. By leveraging the capabilities of i-Tree tools and synthesizing findings from global research, urban planners can optimize tree planting initiatives to deliver maximum environmental, economic, and social benefits.

Conclusion

The extent to which trees contribute to better air quality in cities is revealed by modelling efforts aimed at removing air pollution. When compared to the effects of modelled trees, the effects of public trees in California were determined to have a comparatively minor impact. The findings of the model for the selected tree species suggested a better total CO_2 sequestration capacity and air pollution removal rate than the tree cover that was already existing in the area. These results were obtained by comparing the tree cover to the selected tree species. Urban planners need to take into account the effect that urban trees and green spaces have on the quality of the air in the surrounding area in order to produce better and more educated plans that assure the cleanliness of the air and maintain human health in urban areas.

Recognizing the spatial pattern and variation in the provision of ecosystem services by urban green spaces is essential in light of the fact that urban green spaces are constantly expanding and transforming. The effectiveness of various types of urban green spaces may provide a variety of ecosystem services as a basis for setting future planning goals that are more precise in nature. i-Tree tools could be used to conduct environmental analysis, which would be useful when planning urban green space projects.

Authorship contribution

Project Idea (PI), Funding (F), Database (D), Processing (P), Analysis (A), Writing (W), Review (R), and All (AL). Zeynep Cansu Ayturan: AL; Cezar Kongoli: P, R; Fatma Kunt: PI, D, R.

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