A firefighter extinguishes a flaming palm tree as the Thomas Fire rages through La Conchita south of Carpinteria. (Stuart Palley for the Washington Post)

Which trees cost us most?
How can GIS help us manage or replace them?

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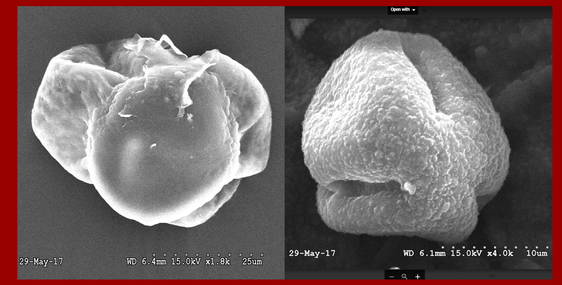


Introduction

Which trees cost us most? Which trees benefit us most? Many people have proposed mitigating climate change and adapting to warmer temperatures by planting trees in order to sequester carbon and provide shade in urban areas (Parker-Flynn, 2018). Unfortunately, many urban areas have been planted with highly allergenic dioecious and monoecious male trees (Ogren, 2015), with costly effects on the allostatic load and quality of life of people who suffer from allergies despite tree- planters' helpful intentions. These trees can cause both the development and the intensification of allergies. The prevalence of asthma and allergic disease has increased dramatically during the past few decades, even outside of industrialized areas (D'Amato, et al, 2011). Urban street tree pollen has the potential to sorb ozone, diesel particulates, formaldehyde, fabric softener perfumes, surfactants, and other urban air contaminants just prior to interacting with people's immune system at their mucous membranes and lungs. Although genetic factors are important, in plants' pollen allergenicity (Asam, 2015) and the development of human asthma and allergies, environmental changes are suspected to cause the intensification of asthma and allergies in most or all human genotypes(Gaudieri, 2012). Increases in carbon dioxide levels in the air have been observed to increase pollen production in allergenic plant species (Irfan, 2012), suggesting that increasing [CO2] and allowing the most allergenic trees to continue growing will cause more people to suffer from more intense allergic symptoms.

Managing or replacing allergenic trees so we can benefit from carbon sequestering and shading benefits is important for urban and suburban resilience in the context of increasing carbon dioxide concentrations. Pollarding, pollard grafting pollen-free branches, and/or male flower removal just prior to pollen emission are all viable strategies for various tree species, practiced in various parts of the world (Ogren, 2015). These practices may also help reduce the risk of starting and propagating fires, reduce overhead power line breakage, reduce consumptive water use, improve electric power reliability, and extend pavement life.

This project seeks to demonstrate a GIS approach to:

1. Identify the most allergenic street trees growing within a city, based on data assembled by a botanical GIS contractor and reported by a publicly available GIS (Geographic Information System).
2. Map the most allergenic street trees, prioritizing them for proposed removal/replacement based on:
   a. their confirmed pollen production and allergenicity,
   b. actual or potential damage to sidewalks, curbs, and roads,
   c. Actual or potential damage to overhead power lines capable of causing fires from wind storm branch-strikes
3. Trim trees away from power lines and maintain better data about where existing tree branches are likely to touch power lines during windy conditions. This tree data and maintenance approach could have better protected power lines and better informed SCE managers who rendered fire-fighters and hydrants powerless to save hundreds of homes from burning. This same approach can improve quality of life for children and adults with asthma and tree pollen allergies.

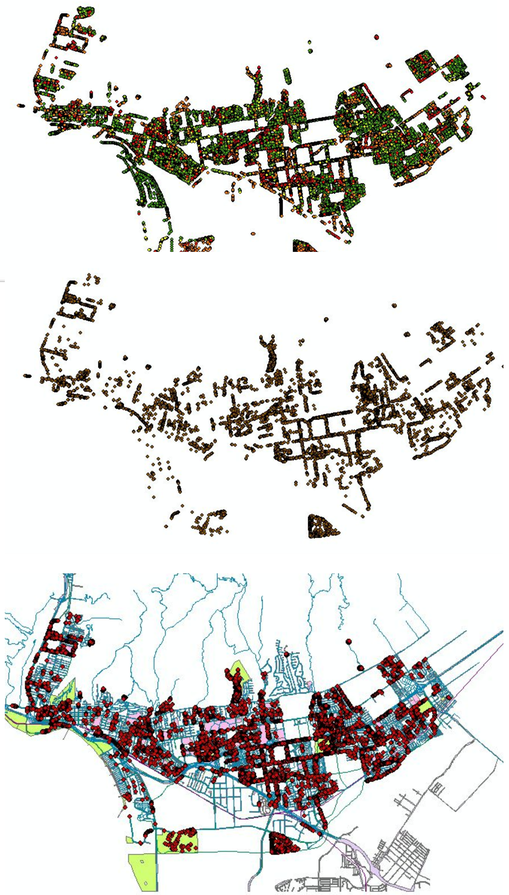
Materials and methods

VenturaMaps City Vector Shape files, geocoded photos, and field data gathered with Survey123 on a smart phone were used as the major sources of data. Tree pollen allergenicity levels were based on OPALS (Ogren Plant Allergenicity Scale), with some minor adjustments based on Asam, 2015.

Results

Urban Forest Arborists have questioned the impact of this approach upon urban forest biodiversity, so that impact was assessed as a percentage of total species. This led to graphing the biodiversity loss associated with the replacement of trees with various levels of allergenicity: 10, 9-10, 8-10, etc. with hypoallergenic trees. An optimal point was sought, balancing urban forest biodiversity with human benefits such as air quality, fire risk management, pavement preservation, and water conservation.

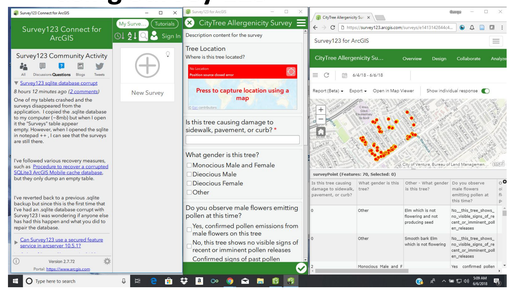
Replacing the most allergenic trees, rated 8, 9, and 10 in the OPALS scale eliminated just under 30% of the biodiversity, with just over 90 tree species targeted for replacement. With further research, biodiversity decreases can be diminished, based on verification that some trees like *Podocarpus* spp. only present allergenic pollen risk if planted trees are male dioecious. Many palms may be found to be less allergenic than this analysis presumed, and many hypoallergenic cultivars can be added to recover the biodiversity of the urban forest.



Geocoded, dated pollen phenology

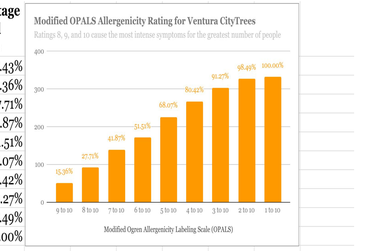
Validation of Trees'

- allergenic pollen production,
- risk of striking power lines, and
- damage to pavement
- using Survey 123



How much biodiversity does the urban forest need?

OPALS	Category Total Species	Percentage of Total Species
10	28	8.43%
9 to 10	51	15.36%
8 to 10	92	27.71%
7 to 10	139	41.87%
6 to 10	171	51.51%
5 to 10	226	68.07%
4 to 10	267	80.42%
3 to 10	303	91.27%
2 to 10	327	98.49%
1 to 10	332	100.00%



This analysis suggests that the City of Ventura could replace all of the most problematic allergy-causing trees and still keep (100-27.71%=) 72.29% of its current biodiversity. There are a variety of healthier, water-wise, and fire-suppressive trees the City of Ventura could choose to plant in order to restore biodiversity.

Conclusions

In the pilot study of over 100 city trees, nonnative evergreen oak trees seemed to cost the most in terms of allergic impacts on human health. Olive trees and bottle-brush trees, also rated high in OPALS, were also found to be flowering at the time of this study but did not seem to have the same allergenic effect and seemed to emit less pollen. Many of these non-native oak trees were found to buckle pavement significantly and grow up to and over and around overhead power lines serving street lights and homes. Many of those same oaks had succor growth that blocked all or part of the sidewalk.

More data of this nature about the presence of power lines and the degree to which trees' branches may strike power lines during high winds could help the City Water Department decrease risk of power outage. Southern California Edison could then decrease the risk of starting fires with overhead power lines snapping due to branch-related-breaks, and improve power reliability. Further research needs to be done to understand the feasibility and cost of allergy desensitization treatment, as well as the civil ramifications of health damages caused by private or public trees. These results suggest that this neighborhood could provide a favorable location for a pilot study to pollard, remove male flowers, and/or replace the most extremely allergenic trees.

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Further information

Next steps include gathering more data with Survey123 or GoogleForms to understand residents' preferences about trees in front of their home, the city's point of view regarding these trees, sourcing new trees, and answering the question of how quickly to proceed. For example, the best alternative may be to pollard or remove male flowers for 5 to 10 years while new trees are given an opportunity to get established, using the allergenic trees as nurse trees.