Towards a North American Urban Tree Spatial Dataset: Leveraging Urban Tree Inventories from 30 Cities in North America

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Introduction

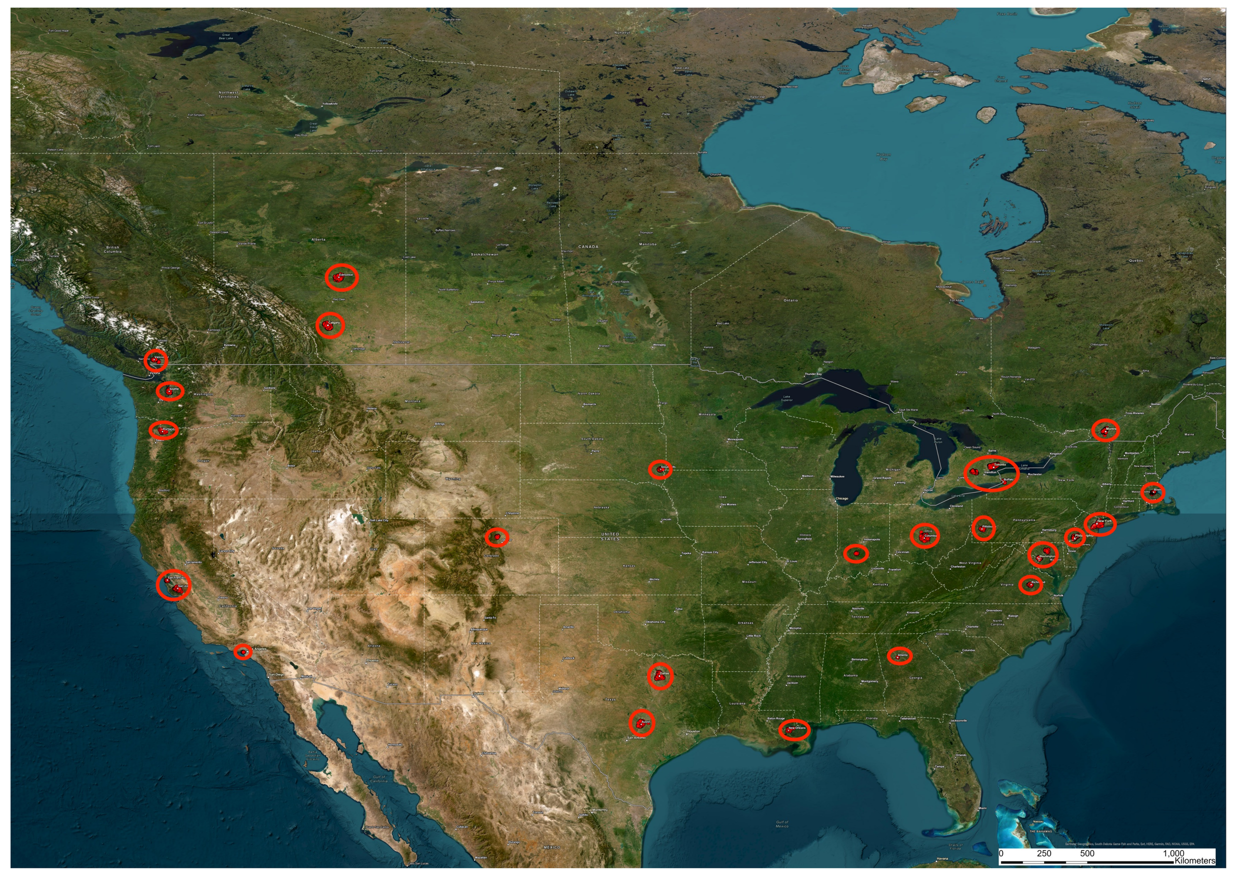
Urban areas face significant environmental challenges driven by anthropogenic influences, as urban landscapes are often characterized by air and noise pollution, habitat loss, and heat island effects. Previous research suggests that urban trees help to mitigate the consequences of urban dwelling. However, the lack of comprehensive spatial information on urban trees at a large-scale has hindered research progress, particularly in quantifying the numerous benefits that urban trees provide, such as carbon storage and air purification. Thus, quantifying urban ecological mechanisms requires a spatially explicit urban tree dataset. While many cities have local urban tree inventories available, there is no large-scale urban tree dataset with spatially explicit information and tree characteristics currently available, which is essential for accurately quantifying carbon storage.

Here, we developed a new North American dataset by leveraging local urban tree inventories from 30 cities across the United States and Canada, capturing over 3.9 million urban trees with standardized measurement systems and tree species names.

We anticipate that the development of a robust, publicly available dataset can facilitate the exploration of large-scale urban ecological dynamics.

Methods

- Collected tree inventory data from 30 cities (2015-2023) and cleaned datasets for standardized measurements and species names (n = 4.7 million trees)
- Conducted tree verification in Google Earth Engine using remotely sensed imagery and Normalized Difference Vegetation Index (NDVI)
  - Utilized Sentinel-2 imagery with 10-meter spatial resolution, ensuring a cloud cover threshold of 1%
- NDVI values greater than or equal to 0.2 (likely tree presence) in 2023 were kept in the post-verification dataset (n = 3.9 million trees)
- Quantified biomass, carbon, and CO_2 stored in individual trees using urban tree allometric equations



Atlanta, Georgia, USA
Austin, Texas, USA
Baltimore, Maryland, USA
Bloomington, Indiana, USA
Boston, Massachusetts, USA
Boulder, Colorado, USA
Buffalo, New York, USA
Calgary, Alberta, Canada
Cambridge, Ontario, Canada
Columbus, Ohio, USA
Cupertino, California, USA
Dallas, Texas, USA
Edmonton, Alberta, Canada
Kitchener, Ontario, Canada
Montreal, Quebec, Canada
New York, New York, USA
New Orleans, Louisiana, USA
Philadelphia, Pennsylvania, USA
Pittsburgh, Pennsylvania, USA
Portland, Oregon, USA
Richmond, Virginia, USA
San Francisco, California, USA
San Jose, California, USA
Santa Monica, California, USA
Seattle, Washington, USA
Sioux Falls, South Dakota, USA
Surrey, British Columbia, Canada
Toronto, Ontario, Canada
Vancouver, British Columbia, Canada
Washington, D.C., USA

Figure 1. Sites of interest.

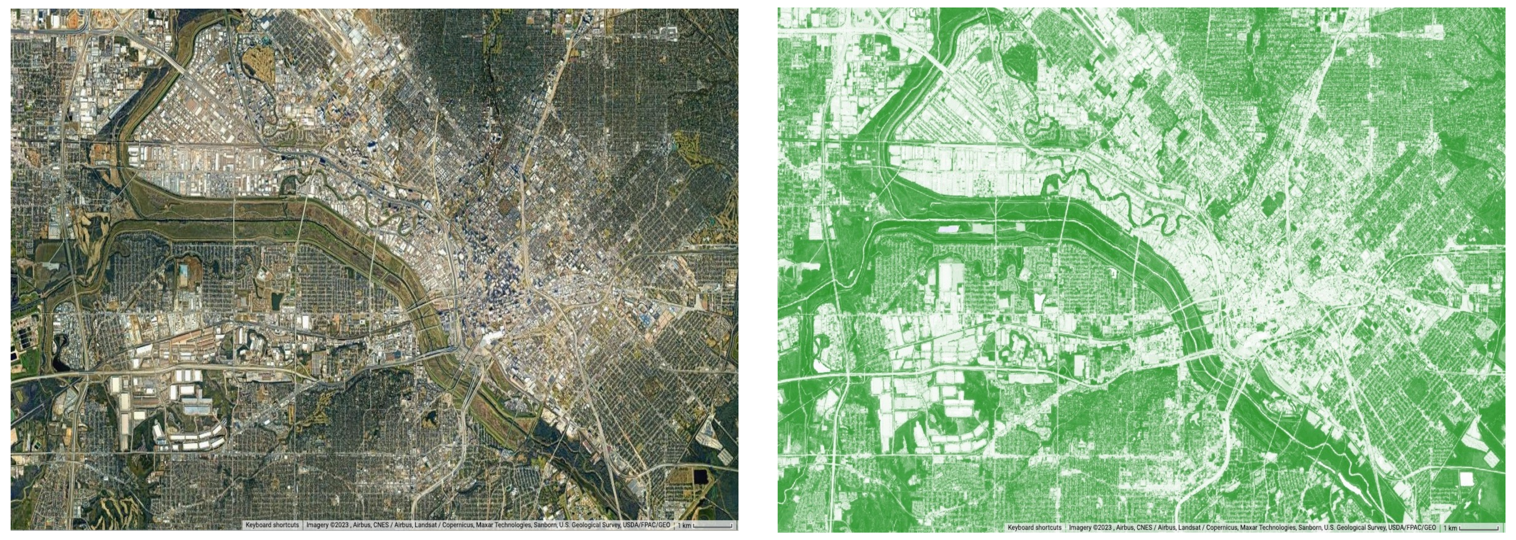


Figure 2. Left: Ten-meter resolution Sentinel-2 satellite image of Dallas, Texas, USA. Right: Ten-meter resolution Sentinel-2 satellite image of Dallas with NDVI calculations, where green indicates vegetation and white indicates no vegetation.

Results

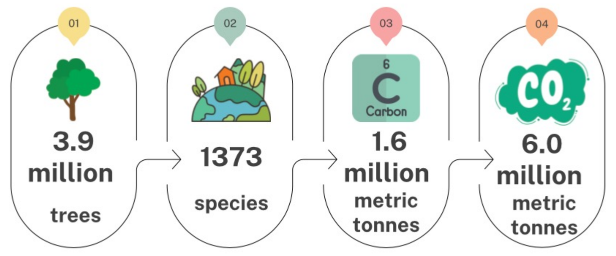


Figure 3. Overview of the dataset. There are 3.9 million trees and 1373 species, storing 1.6 million metric tonnes of carbon and 6.0 million metric tonnes of CO_2.

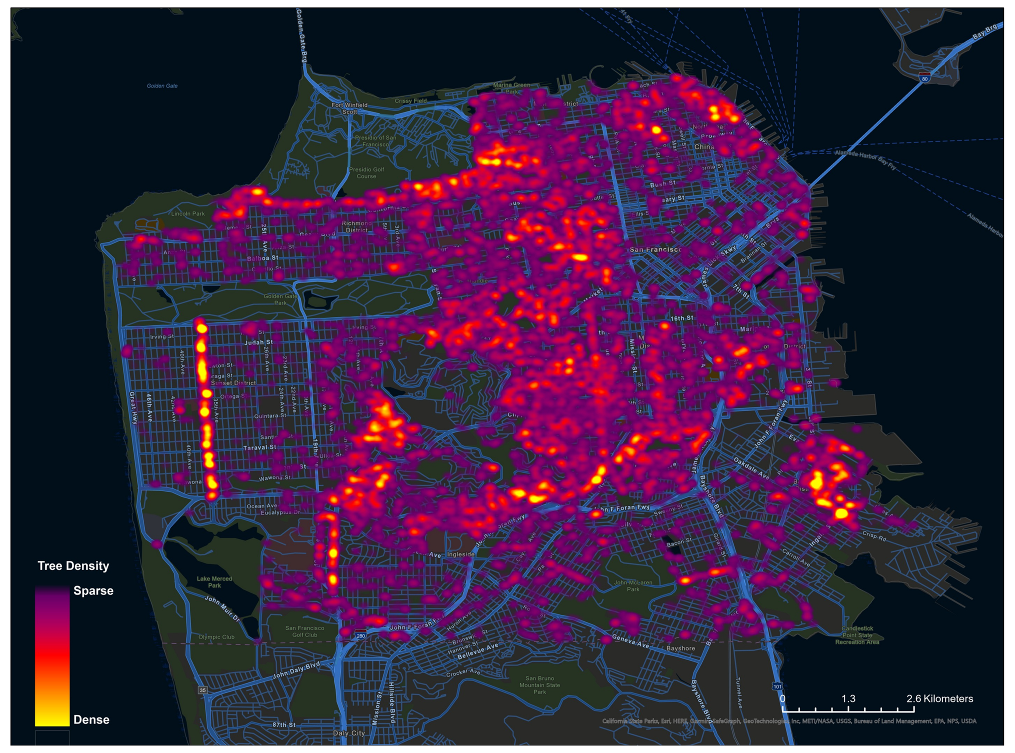


Figure 4. Tree density of San Francisco, California, USA. Hotspots of tree density are yellow, while areas with lower density are purple.

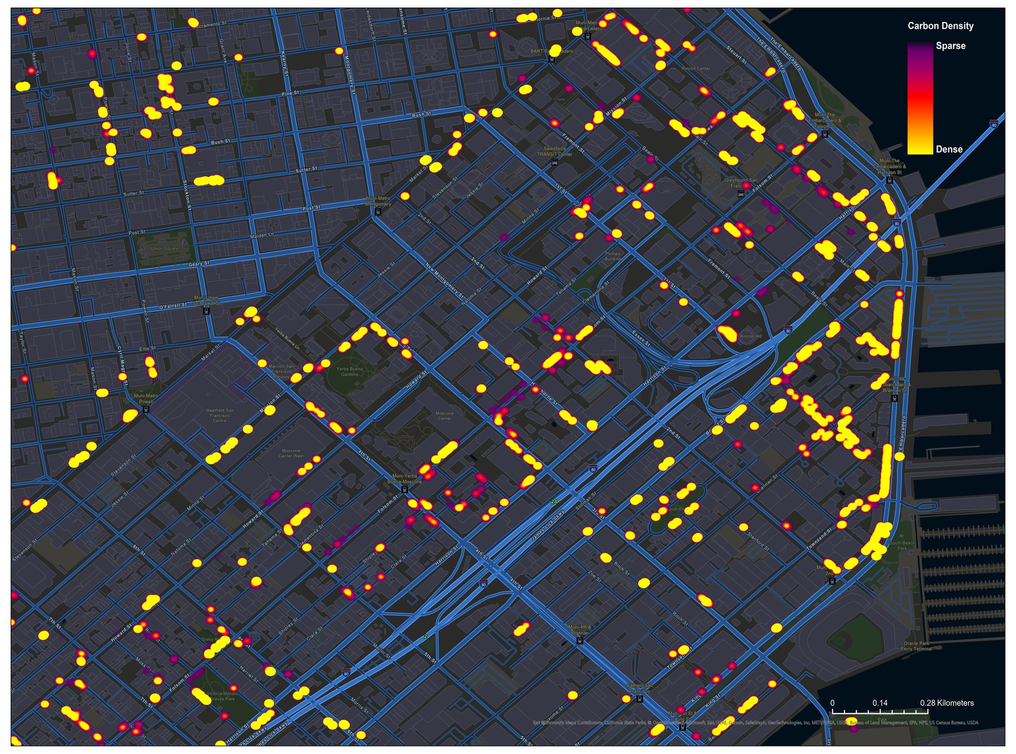


Figure 5. Carbon density of the Yerba Buena neighborhood in San Francisco, California, USA. Hotspots of carbon density are yellow, while areas with lower density are purple.

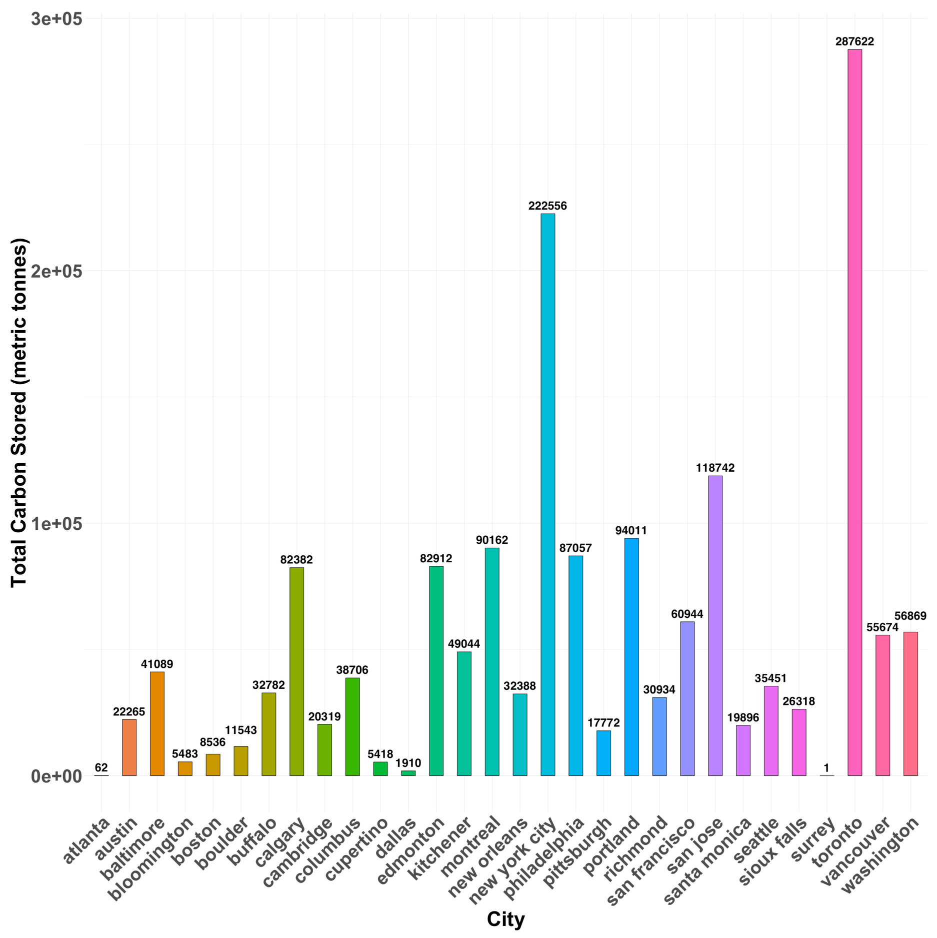
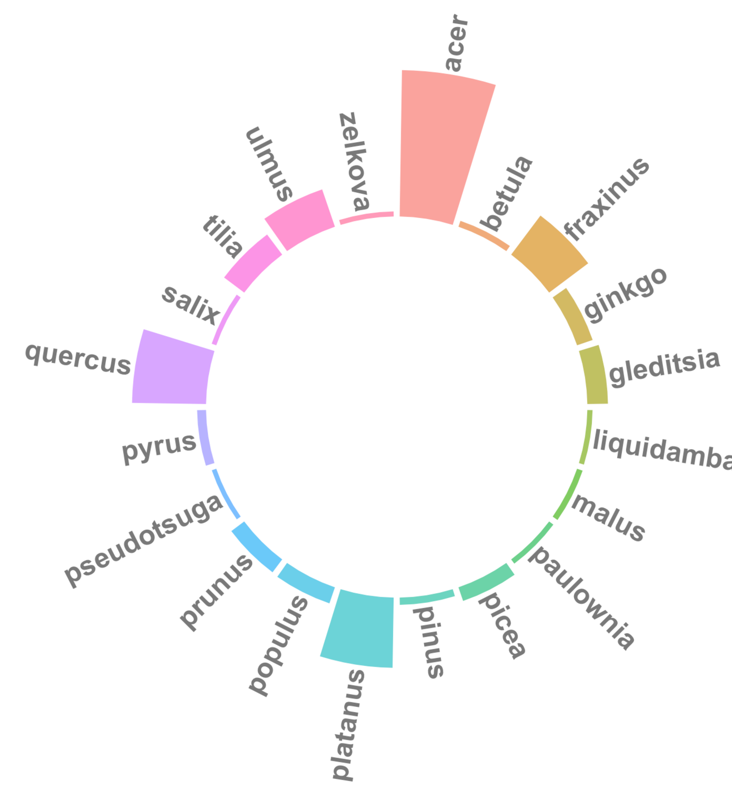


Figure 6. Total carbon stored in metric tonnes by city.



Acer:	383,957,482	kg
Betula:	16,299,555	kg
Fraxinus:	128,051,674	kg
Ginkgo:	43,143,674	kg
Gleditsia:	54,077,417	kg
Liquidambar:	13,675,689	kg
Malus:	15,385,880	kg
Paulownia:	13,767,027	kg
Picea:	37,708,717	kg
Pinus:	19,084,554	kg
Platanus:	184,247,305	kg
Populus:	44,453,810	kg
Prunus:	42,220,631	kg
Pseudotsuga:	12,448,224	kg
Pyrus:	23,376,636	kg
Quercus:	194,016,198	kg
Salix:	12,730,587	kg
Tilia:	65,917,231	kg
Ulmus:	103,476,836	kg
Zelkova:	13,193,901	kg

Figure 7. Total carbon stored by genera. Twenty of the highest carbon storing genera are represented.

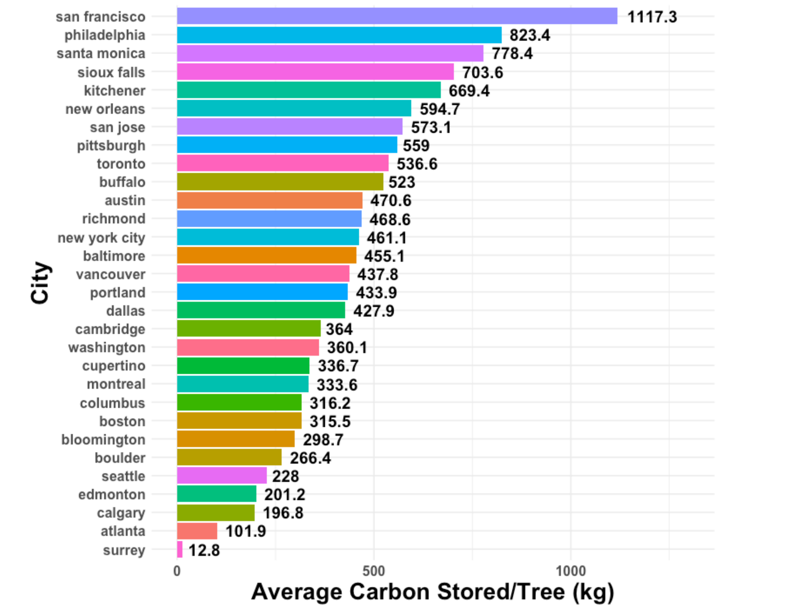


Figure 8. Mean carbon stored within an individual tree by city in kilograms.

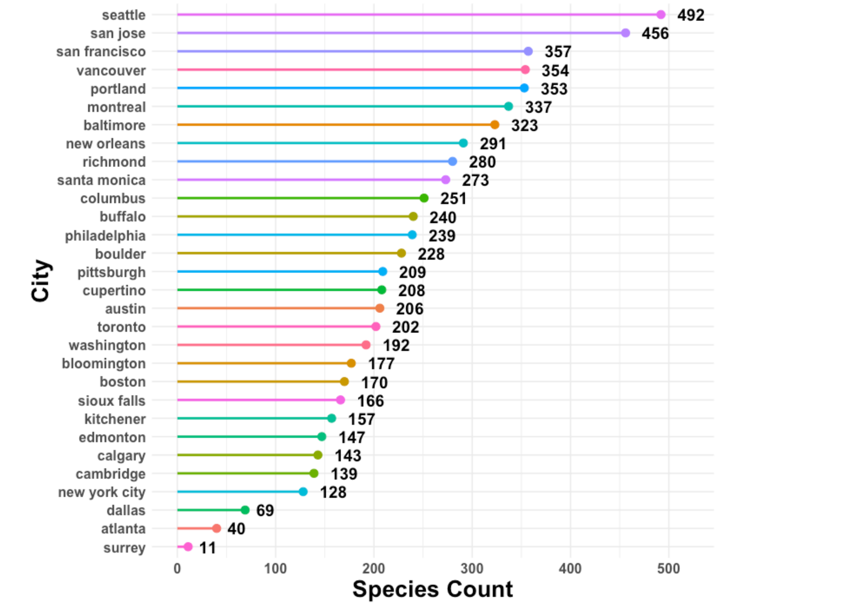


Figure 9. Number of unique species within each city.

Conclusions

Our dynamic dataset facilitates the exploration of a diverse range of continental-scale urban ecological interactions. It encompasses variables such as species diversity, carbon dynamics, and tree diameter, all of which may exhibit spatial variability as influenced by social factors.

This resource proves invaluable in unraveling the intricate dynamics of urban ecosystems and human interactions, providing support for informed decision-making and research on sustainable urban development.

Future Directions

- Rerun using higher resolution imagery (50-centimeter)
- Train a deep learning model to predict presence of urban trees and their crown size
- Further quantify the ecosystem services urban trees provide (i.e., improvements in air quality and stormwater benefits)

Resources

Find the dataset on GitHub:

Acknowledgements

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Knight-Hennessy Scholars
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