

Importance of Big Trees

- Mature trees are considered **'keystone structures'**, providing resources that are crucial for other species (Lindemayer et al. 2013), also referred to as **'foundational species'** (Ellison et al. 2005).
- Cemeteries are considered the **first original parks or green spaces**. In the early 19th century, cemeteries were transitioning from small church grounds into large landscaped tracts. Horticulturists designed unique gardens to engage communities in activities like strolling and picnicking. Early cemeteries often house rare and potentially endangered flora (Yilmaz et al. 2017).
- Large mature trees are more prone to environmental factors such as competition with invasive plants, climatic extremes, air pollution, disease/pests, and habitat fragmentation and loss.



Fig. 1. Various images of Mount Auburn Cemetery, Boston, MA.

Citizen Science

- iNaturalist archiving and crowd-sourcing technology georeferences imagery and can store user-defined field information associated with the project.
- iNaturalist is a network of naturalists who aid in collaboratively identifying biological organisms based on uploaded images and location information (Dickenson et al. 2012; Bowser et al. 2014). Their goal is to have a living record of life on Earth that is readily available for anyone to monitor biodiversity.
- i-Tree Eco V6 is a model that uses data collected in the field from either single trees, complete inventories or randomly located plots in a study area along with local hourly air pollution and meteorological data to quantify forest structure, environmental effects and value to communities.

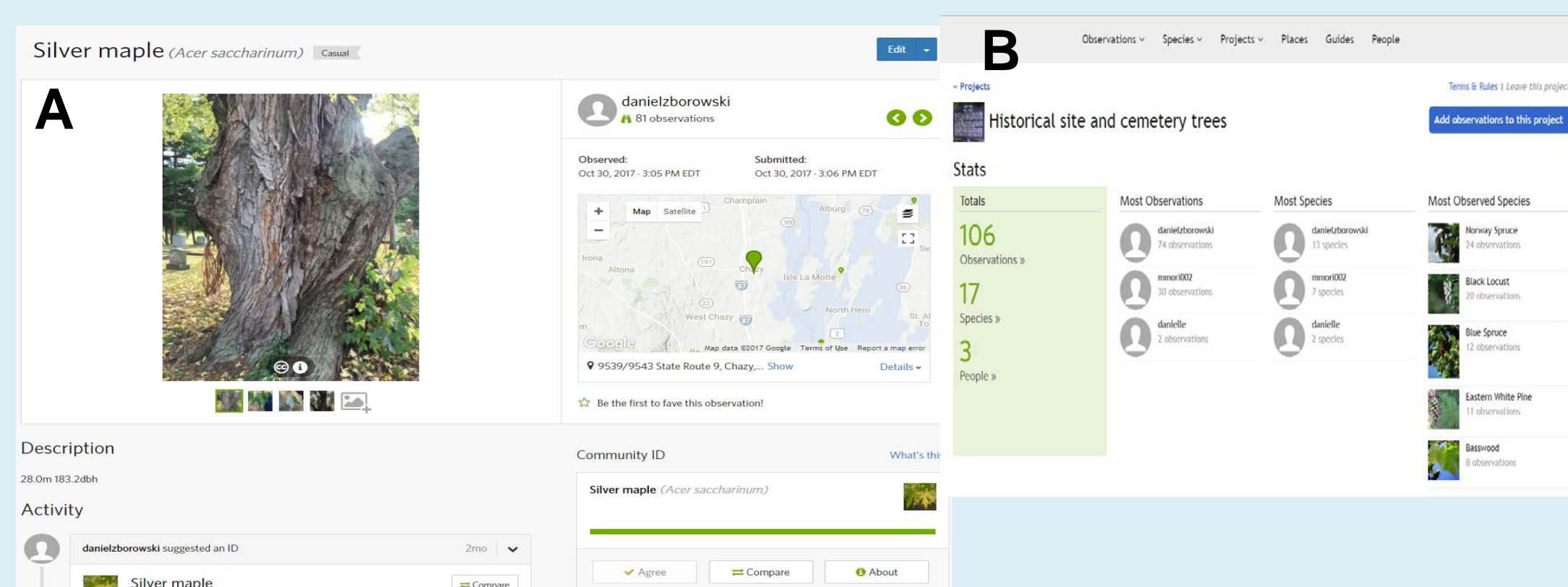


Fig. 2 A) iNaturalist observation displaying images, metrics, as well as GoogleMap of location, B) Summary statistics from the iNaturalist 'Historical Sites and Cemetery Trees' project, including the number of observations, species, and observers.

Goal

- Utilize technology and crowd-sourcing to facilitate ecological sampling.
- Obtain and preserve georeferenced information on tree specimens in cemeteries and historical sites.
- Assess the ecological role of large trees in cemeteries and historical sites.

Methods

- Cemeteries in Clinton and Essex County NY were surveyed for large trees. Metrics included species, dbh (cm) and height (m) using a range finder (Nikon Forestry Pro Ranger Finder).
- Percent crown dieback, as well as signs of disease and woodpecker damage were noted.
- 'Historical Site and Cemetery Trees'** project was created in the iNaturalist program to georeferenced and photo-document (e.g., leaves, bark, silhouette) trees.
 → Quality-control for tree species ID via crowd-sourced naturalists using the app was another important rationale for using iNaturalist.
- i-Tree Eco (V6) was used to model the ecosystem services of cemeteries and historic sites.
 → Services include carbon storage and sequestration, oxygen production, runoff reduction, pollution removal etc.



Fig. 3 A) Melissa measuring tree dbh, B) Melissa obtaining height of a tree in MacDonough Park, C) Pitch pine tree that grew at the base of a grave marker, D) Mature oak tree grown in open space of the Old Catholic cemetery in Plattsburgh, E) Mature pines of Riverside cemetery, F) Mature spruce of Riverview cemetery, G) Riverview cemetery historical marker sign.

Summary Results

| Table 1. Summary statistics from i-Tree Eco V6. | |
|---|--|
| Tree Abundance | 103 |
| Tree Cover | 3.20% |
| Most Common Species | Norway spruce, black locust, blue spruce |
| Pollution Removal | 57.03 kg/yr (\$870/yr) |
| Carbon Storage | 148.7 tonnes (\$21, 300) |
| Carbon Sequestration | 1.302 tonnes/yr (\$186/yr) |
| Oxygen Production | 3.472 tonnes/yr |
| Avoided Runoff | 196.8 m ³ /yr (\$464/yr) |
| Structural Value | \$749,000 |

Ecosystem Services Results (i-Tree Eco)

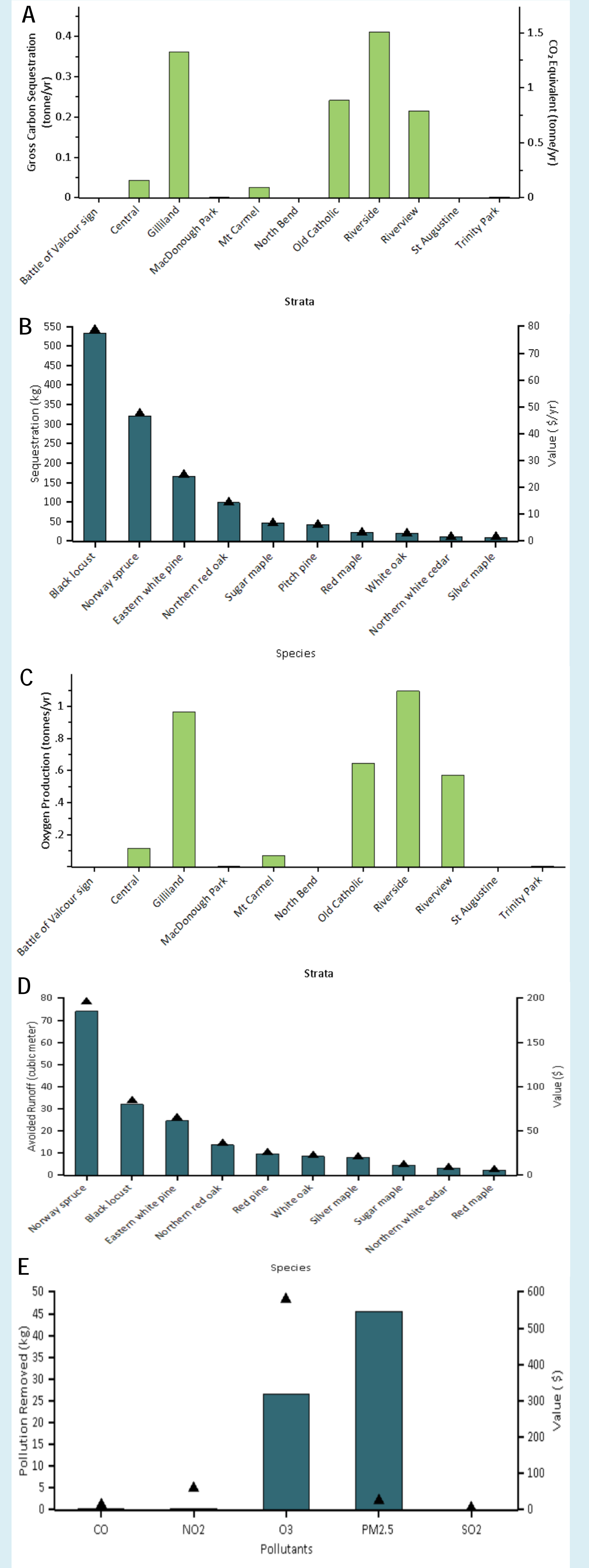
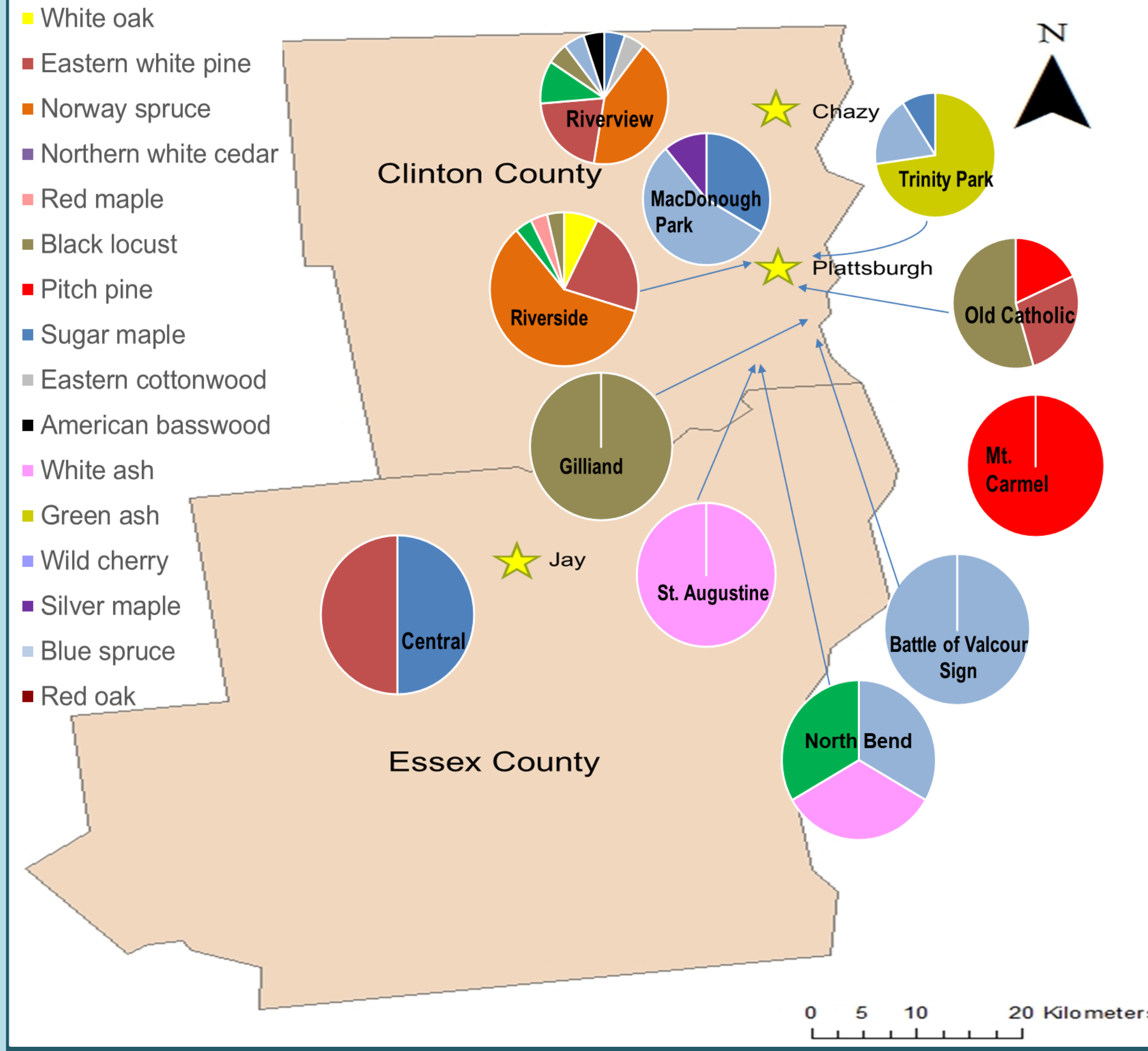


Fig. 4 A) Site-specific annual carbon sequestration (tonnes/yr) and CO₂ (tonnes/yr), B) Species-specific estimated annual carbon sequestration (kg), C) Site-specific oxygen production (tonnes/yr), D) Species-specific annual avoided runoff (m³) and tree value (\$), E) Annual pollution removed (kg) (ozone, particulate matter 2.5 microns) and value (\$) for trees in the project.

Relative Abundance and Richness of Cemetery Trees



Naturalized Tree → Black locust (*Robinia pseudoacacia*)

- Black locust can fix nitrogen and are ruderal in life history (Vitková et al. 2017), increasing N in disturbed floodplains/riparian habitat (Buzhdygan et al. 2016).
 → High N-content litterfall and rapid decomposition alters local water chemistry.
- Populations sexually reproducing have root suckers which appear after the 4th year (Rice et al. 2004).
 → Black locust reproduces vegetatively often referred to as invasive and removed in restoration efforts.



Fig. 5. Black locust at the Gilliland cemetery historical marker.

Discussion

- Since 16% of the cemetery trees are in poor-critical condition, efforts should be made to protect remaining mature trees and replant in order to provide ecosystem services (Lindemayer et al. 2013).
 → In particular, large conifers with heavy cone crops are particularly susceptible to crown damage in microbursts and heavy snows, which are becoming more regionally frequent.
- Black locust establishes in low nutrient habitats, has deep spreading roots, matures early and rapidly to large size before declining and becoming susceptible to bole rot → likely explaining carbon sequestration and storage ability (>40% all trees in project).
- Norway spruce, a species structurally (symmetrical pyramid shape) associated with preventing runoff → riparian cemeteries
- Mature cemetery trees have the ability to mitigate local pollutants (e.g., ozone, particulate matter (2.5 microns on leaves)) associated with human health impacts.
- Greatest species richness → riparian cemeteries "park-like" historic sites

Literature Cited

Bowser, A., Wiggins, A., Shanley, L., Preece, J., & Henderson, S. 2014. Sharing data while protecting privacy in citizen science. *IX Interactions* 21(1): 70-73.

Buzhdygan, O. Y., Rudenko, S. S., Kazanci, C., & Patten, B. C. 2016. Effect of invasive black locust (*Robinia pseudoacacia* L.) on nitrogen cycling in floodplain ecosystem. *Ecological Modelling* 319: 170-177.

Dickinson, L., Shirik, J., Bonter, D., Bonney, R., Crain, R.L., Martin, J., Purcell, K. 2012. The current state of citizen science as a tool for ecological research and public engagement. *Frontiers in Ecology and the Environment* 10(6): 291-297.

Ellison, et al. 2005. Loss of foundational species: consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology and the Environment* 3(9): 479-486.

Lindemayer, D. B., Banks, S. C., Laurance, W. F., Franklin, J. F., & Likens, G. E. (2014). Broad decline of populations of large old trees. *Conservation Letters* 7(1): 72-73.

Rice, S. K., Westerman, B., & Federici, R. 2004. Impacts of the exotic, nitrogen-fixing black locust (*Robinia pseudoacacia*) on nitrogen-cycling in a pine-oak ecosystem. *Plant Ecology* 174(1): 97-107.

Vitková, M., Müllerová, J., Šádlo, J., Pergl, J., & Pyšek, P. 2017. Black locust (*Robinia pseudoacacia*) beloved and despised: A story of an invasive tree in Central Europe. *Forest Ecology and Management* 384: 287-302.

Yilmaz, S., Duzenli, T., & Dincer, D. 2017. Evaluation of factors related to well-being effects of urban green spaces on users. *Fresenius Environmental Bulletin* 26(12A): 7789-7800.