Summer 2024 Project Summary

Central Park Ecological Conservation

Assessing Tree Health Conditions in New York City's Central Park with NASA Earth Observation Data

Project Team

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Project Overview

Project Synopsis:
As stewards of New York City's iconic Central Park, the Central Park Conservancy diligently preserves one of the largest and last remaining collections of American elm trees in the world. This culturally significant species is endangered due to the spread of Dutch elm disease. This project investigates the feasibility of integrating remote sensing into the Conservancy's forest management and decision-making. Landsat 8 and 9 imagery of the park from 2014 to 2023 are used to quantify changes in tree canopy health and detect recorded occurrences of trees infected with the disease.

Abstract:
The Central Park Conservancy stewards New York City's iconic Central Park with a mission to preserve the park for all. This mission is complicated by the spread of Dutch elm disease (DED) which has endangered the culturally and ecologically significant American elm tree (*Ulmus americana*). Central Park is home to one of the largest and last remaining collections of American elm and the Conservancy currently protects them through integrated pest management. This paper discusses an interdisciplinary feasibility study that assessed the application of NASA Earth observations from 2014 to 2023 to detect changes in forest phenology possibly due to DED. Landsat 8 and 9 imagery was used to calculate multiyear time series of the normalized difference vegetation index (NDVI) and quantify changes in land surface phenology for a given year. A pixel-based logistic regression was performed using changes in NDVI, tree site locations, and recorded occurrences of trees infected with DED as inputs. The results of this regression show that changes in NDVI derived from Landsat data are feasible for detecting unhealthy tree canopies with 71% accuracy and healthy tree canopies with 41% accuracy. The study had uncertainties and limitations due to the spatial and temporal resolutions of Landsat, the natural variability in land surface phenology and NDVI, and the attempt to detect disease impacts while disease prevention is active. As is, the findings of this study and its methods provide managers with an approach for integrating Earth observations to make more informed decisions in the application and timing of urban forest management.

Key Terms:

Central Park, remote sensing, urban forest management, pest management, Landsat, Normalized Difference Vegetation Index, American elm, Dutch elm disease

Application Area: Ecological Conservation
Study Location: Central Park, New York City, NY
Study Period: 2014 to 2023 (April to September)

Community Concerns:

- As stewards of Central Park, the Central Park Conservancy is responsible for its preservation for all to enjoy. An essential part of this mission includes caring for all trees in the park's urban forest.
- Central Park is home to one the largest and last remaining collections of American elm trees in the world. This species is endangered due to the spread of Dutch elm disease, which is caused by an invasive fungus spread by the Elm bark beetle and through tree roots.
- The Conservancy aspires to integrate remote sensing into its forest management so that it can make more informed decisions about the application and timing of measures taken to prevent the spread of pests and diseases.

Project Objectives:

- Quantify changes in land surface phenology from 2014 to 2023 using Landsat 8 and 9 imagery
- Understand the factors that contribute to the spread of Dutch elm disease
- Validate the detection of recorded occurrences of trees infected with Dutch elm disease using the status of tree canopy health

Partner Overview

Partner Organization:

Organization	Contact	Partner Type	Sector
Central Park Conservancy	Sean Cameron, Manager of Data Systems; Yanina Kupava, Director of Operational Planning & Administration	End User	Non-profit

Decision-Making Practices & Policies:

The Conservancy protects American elms and other trees in the park through integrated pest management, a comprehensive approach that considers the life cycles of pests and their interactions with the environment. Their forest management plan follows a comprehensive cyclical approach that operates over 7-year periods. Certified arborists perform a risk assessment for trees in the park through regular inspections and biological sample testing to determine. Special projects in the park, including integrated pest management tasks, require increased coordination and precise timing to ensure their efficacy. The Conservancy takes a proactive approach to this process by predicting when these special projects will occur based on previous projects and identifying trends in the timing of cyclical biological events of pests and trees.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameter	Use
Landsat 8 Operational Land Imager	Normalized Difference Vegetation Index (NDVI)	Calculation of NDVI time series and change maps over the study period as a proxy for changes in land surface phenology.

Landsat 9 Operational Land Imager 2	Normalized Difference Vegetation Index (NDVI)	Calculation of NDVI time series and change maps over the study period as a proxy for changes in land surface phenology.

Ancillary Datasets:

- NYC Office of Technology and Innovation Land Cover Raster Data (2017) – Filtered for tree canopy pixels to derive a tree canopy polygon
- NOAA Global Historical Climate Network Daily Summaries – Temperature and precipitation observations used to calculate Growing Degree Days and analyze trends in seasonality
- Central Park Conservancy Tree Data – In-situ measurements used to estimate an elm-only tree canopy polygon and validate the detection of Dutch elm disease

Software & Coding Languages:

- Google Earth Engine – Acquisition of Landsat 8 and 9 imagery and calculation of NDVI time series analysis
- Python – Logistic regression to validate recorded occurrences of Dutch elm disease with changes in the status of tree canopy health
- R – GAM's analysis to determine the start and end of the growing season, analysis of the relationship between temperature, precipitation, and Growing Degree Days
- ArcGIS Pro – Raster manipulation, creation of study area maps and NDVI change maps, and creation of a package file for sharing all layers

End Products:

End Products	Data Used	Partner Benefit & Use
NDVI Change Maps	Landsat 8 OLI, Landsat 9 OLI-2	The partner can assess changes in land surface phenology at the pixel level compared to a baseline of the entire study period.
Changes in Seasonality and Growing Degree Days	NOAA Global Historical Climate Network Daily Summaries	The partner can assess changes in the timing of seasons and Growing Degree Days (GDD), as well as the effects of temperature and precipitation on GDD. The partner can use this to make more informed decisions about the timing of their pest management.
Logistic Regression Validation	Landsat 8 OLI, Landsat 9 OLI-2, Central Park Conservancy Tree Data	The findings of the validation, along with changes in land surface phenology, can be used to establish a relationship between changes in NDVI and recorded occurrences of Dutch elm disease at the pixel level. This can be used to develop a model that predicts future occurrences.
GIS Tutorial	Landsat 8 OLI, Landsat 9 OLI-2	The partner will be able to reproduce our methods to continue developing the capacity to utilize Earth observations in their decision-making.

Product Benefit to End User:

The findings of this project demonstrate how NASA Earth observations can be used with in-situ data to quantify changes in land surface phenology, seasonality, and Growing Degree Days. These findings can be incorporated into the Conservancy's decision-making, allowing it to make more informed decisions in the application and timing of its pest and forest management. The results of the validation show that it is possible to detect unhealthy tree canopies at the pixel level, and with further research, could be used to create and improve a prediction model that forecasts future occurrences of Dutch elm disease. These methods can be easily replicated using the GIS Tutorial, and they can be applied to other Earth observations with higher spatial and temporal resolutions to increase the precision and accuracy of the results. The end products ultimately support the Conservancy's efforts to be more proactive in their approach to pest and forest management.

References

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Caparros-Santiago, J. A., Rodriguez-Galiano, V., & Dash, J. (2021). Land surface phenology as indicator of global terrestrial ecosystem dynamics: A systematic review. *ISPRS Journal of Photogrammetry and Remote Sensing*, *171*, 330–347. https://doi.org/10.1016/j.isprsjprs.2020.11.019

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