NASA DEVELOP National Program
2024 Fall Project Proposal

Maryland – Goddard
Illinois Ecological Conservation
Using Earth Observations to Identify Areas of Oak Decline in Illinois and Investigate Contributing Risk Factors

Project Overview

Project Synopsis: A concerning phenomenon known as rapid white oak mortality is emerging in the Midwest, suspected to be linked to winter droughts followed by consistently wet springs, herbicide drift, and oomycete pathogens. The Morton Arboretum in Illinois is conducting physical testing of the soil and trees but seeks to enhance their research with remote sensing. The DEVELOP team will utilize Landsat 5 TM, Landsat 8 OLI, and Landsat 9 OLI-2, Sentinel-2 MSI data to create vegetation indices and explore how climatic and topographic variables impact oak health, aiding in the identification of stressed and dying oak stands across Illinois.

Study Location: Shawnee National Forest and Kaskaskia River Basin
Study Period: 2010 – 2024 (March - September)

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Partner Overview

Partner Organization:

Organization	Contact (Name, Position/Title)	Partner Type	Sector
The Morton Arboretum	Dr. Fredric Miller, Senior Research Scientist, Entomology	End User	Non-profit

End User Overview

End User's Current Decision-Making Process & Capacity to use Earth Observations: The Morton Arboretum currently relies on ground-truthing methods to identify stressed oak stands and collect field data on tree root samples, site and soil data, and pest and disease information. Arboretum staff aim to understand the roles of various biotic and abiotic factors in oak decline and death. While remote sensing is not currently involved in their decision-making process, they recognize the potential of NASA Earth observations to enhance their efforts. Incorporating Earth observation data will enable them to efficiently pinpoint stressed oak forests, saving time and resources in data collection and help inform decision-making for grant fund use. This project will build the partner's capacity by integrating remote sensing technologies to improve their resource allocation process and enhance effectiveness of their field data collection efforts.

Earth Observations Overview

Earth Observations:

Platform & Sensor	Parameter	Use

Landsat 5 TM	Spectral vegetation indices	This dataset will provide the temporal (16 days) and spatial (30 m^2) resolution needed to track stand health from 2008 until 2015.
Landsat 8 OLI	Spectral vegetation indices	This dataset will provide the temporal (16 days) and spatial (30 m^2) resolution needed to track stand health from 2015 to 2024.
Landsat 9 OLI-2	Spectral vegetation indices	This dataset will provide the temporal (16 days) and spatial (30 m^2) resolution needed to track stand health from 2015 to present.
Sentinel-2 MSI	Spectral vegetation indices	This dataset will provide the temporal (5 days with constellation) and spatial (10 m^2) resolution needed to track stand health from 2015 to present.

Ancillary Datasets:

- USDA Forest Service: National Insect & Disease Risk and Hazard Mapping Portal – compare individual tree species maps to vegetation indices and forest health indicators
- USDA Forest Service: National Individual Tree Atlas – delimit concentrations of oaks within the proposed study area(s) and identify specific tracts of forest that are oak dominated for vegetation index maps
- USDA National Agriculture Imagery Program (NAIP) – validate location of identified stressed and dying trees via vegetation index maps and supplementary datasets
- USGS 3D Elevation Program (3DEP) Digital Elevation Model (DEM) – create topographic variables such as slope and aspect
- Surface Elevation: 301-Foot Digital Elevation Model (DEM) – 3DEP DEM alternative
- Illinois Climate Network: Weather Data – climatic variable inputs for the linear/multiple linear regression model
- NASA ORNL DAAC at Oak Ridge National Laboratory Daymet – climatic variable inputs for linear regression model (Illinois Climate Network alternative)
- University of Idaho gridMET – climatic variable inputs for the linear/multiple linear regression model, including drought indices (Illinois Climate Network alternative)
- GridMET DROUGHT: CONUS Drought Indices – drought indices as inputs into the linear/multiple linear regression model
- NASA SPoRT LiS Soil Moisture Products – high resolution (about 3km) gridded soil moisture products for drought assessments and regression model input
- NASA North American Land Data Assimilation System (NLDAS) – vegetation class and vegetation parameter data for use in the oak decline risk analysis
- National Climate Assessment Land Data Assimilation System (LDAS) – evapotranspiration trends, flooded area, total precipitation rate, daily maximum and minimum air temperature, soil moisture content at 0-200 cm depths, soil temperature, and other key variables for the oak decline risk analysis
- USDA Cropland Data Layer (CDL) – crop type and land cover type data for use in the herbicide drift risk analysis and overall oak decline risk maps

Modeling/Tools:

- Unsupervised classification (POC: Joseph Spruce, AMA Inc.) – model relationships between deciduous forest health and abiotic conditions. The team will use the unsupervised classification to generate risk probability maps in ArcGIS Pro.

Decision Support Tool & End Product Overview

End Products:

End Product	Partner Use	Datasets & Analyses
Drought and Precipitation Time Series Maps	The drought and precipitation time series will be used to investigate the relationship between these abiotic factors and oak decline risk in Illinois. Partners are particularly interested in using the time series to test their climatic variable hypothesis that wet springs contribute to oomycete buildup, limiting root system resilience and contributing to rapid decline from drought.	SPoRT LiS Soil Moisture Data, Illinois Climate Network Weather Data, and National Climate Assessment LDAS datasets will be used to investigate the relationship between climatic parameters such as total precipitation rate, flooded area, and root zone moisture content data, and oak stand health. GridMET Drought Indices will be used to map precipitation anomalies in ClimateEngine. These time series will also serve as inputs for the oak decline risk probability analysis.
Slope and Aspect Maps	Slope and aspect maps will be used to identify potential patterns in relationships between slope/aspect and oak health. Partners have noticed a relationship between oomycete pathogen presence and slope, shallow rooting depth, and heavy clay soils from field surveys. Partners are interested in mapping these relationships on a broader scale than cost-inefficient oomycete field testing methods can provide.	USGS 3DEP DEM, Surface Elevation: 301-Foot DEM will be used to generate slope and aspect maps in ArcGIS Pro to compare with vegetation index maps and investigate potential relationships between slope/aspect and oak stand health.
Georeferenced Vegetation Index Maps	Vegetation indices will help the partner understand specific locations of stressed or dying trees to better target testing efforts. This information on hotspots for oak decline and ill-health is important for deciding where to prioritize oak sampling efforts.	Landsat 5 TM, Landsat 8 OLI, Landsat 9 OLI-2, and Sentinel-2 data will be used to create vegetation indices, including NDVI. Red-edge indices will be calculated using Sentinel-2 MSI to detect pre-visual stress in trees at 20 meters.
Proximity to Commodity Crop Field Maps	This proximity to commodity crop fields analysis and the resulting maps will allow the partner to better understand relationships between oak decline and potential herbicide drift exposure. These maps will show spatial relationships between deciduous forest health and response and proximity to commodity crop fields.	Proximity to commodity crop fields will serve as a proxy for risk of exposure to herbicide drift and will be used to characterize levels of risks for forests near agricultural lands. The USDA Cropland Data Layer will be used to identify location of commodity crop fields in the study region. Herbicide drift risk to oaks will be assessed by creating a buffer around commodity crops and flagging locations downwind from potential herbicide applications.
Oak Decline Risk Severity Heat Maps	The risk maps will be used to identify high-priority areas for oak health monitoring and grant fund allocation.	Risk severity heat maps will be created for 2023 using ArcGIS Pro. USDA NIDRM will be used to

	These maps and related plots will help the partner to better understand the relationships between slope, topographic position, climatological variables like drought, indices calculated from DEMs, proximity to herbicide applications, and oak health.	identify oak stands and concentrations of white oaks within the study area. SMAP and NLDAS Soil Moisture Model/Drought Monitor, Landsat 5 TM, Landsat 8 OLI, Landsat 9 OLI-2, and Sentinel-2 data and other data listed above will be used to model relationships between oak stand health and climatic, topographic, and herbicide drift variables. Proximity to commodity crop fields will be used as a proxy for risk to herbicide drift exposure in the regression model. If time allows, risk maps will be created on an annual basis throughout the study period.

Project Timeline & Previous Related Work

Project Timeline: 1 Term: 2024 Fall

Similar Past DEVELOP Projects:

- 2024 Summer (GSFC) – Southern Indiana Ecological Conservation: https://www.devpedia.developexchange.com/dp/index.php?title=Southern_Indiana_Ecological_Conservation_GSFC_Summer_2024
- 2024 Spring (PUP) – Intermountain West Wildland Fires: https://www.devpedia.developexchange.com/dp/index.php?title=Intermountain_West_Wildland_Fires_PUP_Spring_2024
- 2021 Spring (CO) – Colorado Front Range Disasters: https://develop.larc.nasa.gov/2021/spring/ColoradoFrontRangeDisasters.html
- 2019 Summer (MA) – Southern Maine Health and Air Quality: https://develop.larc.nasa.gov/2019/summer/SouthernMaineHealthAQ.html

Notes & References:

Notes:

- Bipartisan Infrastructure Law (BIL) Illinois State Funding Proposal for Identification of Factors Leading to Oak Decline
- *Phytophthora* Species Detected in Two Ozark Forests with Unusual Patterns of White Oak Mortality
- Progress on Forest Health, BIL State Forest Action Plan Implementation (SICH) Activities
- Conservation Gap Analysis of Native U.S. Oaks
- Injury on White Oak Seedlings from Herbicide Exposure Simulating Drift

References:

Reed, S. E., English, J. T., & Muzika, R. M. (2016). Investigation of Rapid White Oak (Quercus alba) Mortality within the Ozark Plateau and Adjacent Forest-Prairie Transition Ecoregion (Project NC-EM-B-13-01). *In: Potter, Kevin M.; Conkling, Barbara L., eds. 2016. Forest health monitoring: national status, trends, and analysis 2015. Gen. Tech. Rep. SRS-213. Asheville, NC: US Department of Agriculture, Forest Service, Southern Research Station. 226*, *213*, 127-133.

Mirhashemi, H., Ahmadi, K., Heydari, M., Karami, O., Valkó, O., & Khwarahm, N. R. (2024). Climatic variables are more effective on the spatial distribution of oak forests than land use change across their historical range. *Environmental Monitoring and Assessment*, *196*(3), 289. https://doi.org/10.1007/s10661-024-12438-z