NYWGF RESEARCH - FINAL REPORT

Funding for fiscal year: 2024-2025

SECTION 1:

Project title: Linking observations of Spotted Lantern Fly with Tree of Heaven and transit corridors to predict SLF risk to NY state vineyards using remote sensing

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New Research ☒ **Continued Research** ☐

Amount Funded $ $22,500

SECTION 2:

Project Summary Impact Statement:

The aim of this project was to develop risk assessment model for NY vineyards based on habitat suitability of spotted lanternfly (SLF, *Lycorma delicatula).* In 2024 spotted lanternfly were found in the Finger Lakes region of New York, one of the primary grape-growing regions in the state, located more than 200 miles away from the site of its initial introduction. Correlative species distribution models have been widely utilized to estimate landscape habitat suitability and climate change impact on both native and invasive species and have proven useful in guiding policymaking. These models establish statistical relationships between a species' current geographic distribution and relevant climatic parameters, enabling researchers to predict potential spread which can then be used for landscape and regional risk assessment. In anticipation of the risk to New Yorks grape growing industry, the New York State Department of Agriculture and Markets initiated a statewide spotted lanternfly monitoring effort in 2020 that has since collected over 23,000 observations of both spotted lanternfly and tree-of-heaven. Citizen science iNaturalist observations provide an important additional dataset of tree-of-heaven distribution across New York State. Furthermore, we quantified the risk spotted lanternfly poses to the New York wine and grape industry using tree-of-heaven suitability, spotted lanternfly suitability and vineyard density across the state.

Objectives:

1. Combine observational data of tree-of-heaven to define a baseline distribution of TOH across New York

2. Use observational data from objective 1 to quantify tree-of-heaven habitat suitability across New York state beyond observed locations using remote sensing
3. Develop a risk-assessment model that includes TOH habitat suitability, spotted lanternfly suitability and NY vineyard location across the landscape
4. Quantify the potential risk of spotted lanternfly establishment for New York vineyards under both current and future predictive modeling. Work with select NY vineyards identified by the model to be at higher risk to initiate SLF monitoring

Materials & Methods:

Objectives 1-3 were prioritized since this project was funded at 63% of the requested amount.

Objective 1:

We acquired datasets of tree-of-heaven observations from the New York State Department of Agriculture and Markets (N = 11,217) and an additional 10,926 from the Global Biodiversity Information Facility (GBIF). These combined datasets resulted in a total of 22,143 georeferenced locations of tree-of-heaven across New York State. NYSDAM also shared 10,143 verified spotted lanternfly georeferenced locations observed between 2020 and 2024 in New York State.

Objective 2:

To model both tree-of-heaven and spotted lanternfly habitat suitability, quarterly and monthly mean climatic variables were downloaded via CHELSA CMIP6 ISIMIP3 version 2.1. We also assessed the importance of 15 climatic variables. CHELSA data estimates of these variables from 2011-2040, under RCP 7.0, were considered a reasonable reflection of current conditions. Geographic and climatic variables were also included to develop the tree-of-heaven habitat suitability model. Mean 30-arc sec Digital Elevation Model via U.S. Geological Survey GMTED 2010 files were used to obtain the topographic position and elevation of New York State. The soil properties dataset consisted of three raster datasets describing the following soil properties: available water capacity, field capacity, and soil porosity.

Two additional remote sensing variables were assessed for their importance in defining tree-of-heaven habitat suitability, the Normalized Difference Vegetation Index (NDVI) and forest edge habitat. NDVI is an effective measure of vegetation productivity, but also characterizes differential nitrogen and chlorophyll levels, as well as crop vigor and biomass. Mean values of NDVI between August 1, 2023, and November 1, 2023 from Sentinel-2 Harmonized Multispectral Instrument (MSI) were used to characterize New Yorks' autumn season. Tree-of-Heaven is a highly shade-intolerant species that thrives in disturbed, high-light environments, including forest edges, canopy gaps, roadsides, and open fields. Dense, mature forests with canopy cover exceeding 50% inhibit TOH establishment and persistence due to insufficient light availability. To account for the effect of this landscape-level variable on habitat suitability, the Landsat dataset (2010; version 4) was reclassified to include only 30m squares across the state that had less than 40% forest canopy cover, these areas were considered forest edge.

By using the observational dataset of tree-of-heaven locations and spotted lanternfly locations across the state, machine-learning models were developed to identify the most important variables (climatic, geographic and remotely sensed variables) driving habitat suitability. A K-fold cross-validation approach with spatial blocks was implemented to minimize spatial autocorrelation and ensure an independent dataset for validation, resulting in a balanced presence-absence dataset.

Objective 3:
To assess vineyard risk, we created a 10-km buffer zone around each vineyard location to define the habitat proximal to vineyard polygons. The 90th percentile of habitat suitability for both tree-of-heaven and spotted lanternfly were multiplied within each buffered vineyard area. This statistical measure was selected to represent extreme habitat suitability conditions rather than average conditions, ensuring that areas of high risk were effectively identified. An Inverse Distance Weighting (IDW) function was applied to vineyard locations across New York State. The vineyard point layer served as the input dataset, with the newly calculated risk index field used as the Z-score parameter. The Z-score parameter serves as the input for estimating spatial risk patterns at unsampled locations based on vineyard proximity. The power parameter (p) was set to three to ensure that high risk regions were well delineated, while distant points had little to no influence. Finally, the IDW raster output was masked based on the spatial extent of New York State showcasing a final vineyard risk map. The vineyard risk map showcases a gradient representation of vineyard risk across New York State, categorizing regions into various risk zones based on tree-of-heaven and spotted lanternfly interactions.

Results/Outcomes/Next Steps:

Objectives 1 & 2:
Forest edge was identified as an important variable for spotted lanternfly habitat suitability, defined by 40% or less forest coverage in each 30m x 30m square across the entire state. The climatic and geographic variables driving regional differentiation for tree-of-heaven in New York are annual growing degree days (above 0°C), mean daily minimum air temperature of the wettest quarter, net primary production, soil properties, and the mean daily minimum air temperature of the coldest month. Long Island and Hudson Valley were identified as moderate-to-very high in suitability, whereas Lake Erie and the upper regions of the Finger Lakes were identified as low-to-moderate suitability and moderate-to-high suitability in the lower regions of the Finger Lakes (Fig 1).

We used the habitat suitability model for tree-of-heaven developed in Objective 2 as a predictor variable for spotted lanternfly habitat suitability in New York. Using a Random Forest with K-fold cross-validation and spatial blocks approach our model performed well. To model current environmental conditions we again used CHELSA environmental variables for the 2011-2040 time period. For the future climate risk environmental conditions we used projections for 2041-2070 under the worsening emissions scenario (8.5). The top six most influential explanatory variables, according to the Mean Decrease Gini index, for modeling the spotted lanternfly under both current and future climate scenarios were mean daily mean air temperature of the wettest quarter, tree-of-heaven index, human influence index, temperature seasonality, precipitation seasonality, and isothermality (a measure of daily variation relative to annual temperature variation). Currently, the Hudson Valley was identified as moderate-to-very high in suitability for spotted lanternfly, whereas Lake Erie and Long Island wine growing regions seem to have lower suitability, while the Finger lakes region shows areas of both lower and higher suitability (Fig. 2).

Objective 3:

Under current conditions, vineyards in the Hudson Valley region are estimated to be at the highest risk due to the combined effects of tree-of-heaven suitability, spotted lanternfly suitability and vineyard proximity (Fig 3). Estimated risk reaches approximately 76% in that region. The Finger Lakes region exhibits variability in risk, ranging between 15% and 50%. The Long Island region and Lake Erie regions show lower suitability. According to our findings, Long Island and Hudson Valley show increased suitability under a worsening emissions scenario from 2041-2070, whereas the upper regions of the Finger Lakes show heterogenous increases in suitability for spotted lanternfly (Fig 4).

Next steps:

There is a critical need for spatiotemporal machine-learning modeling that incorporates preferred plant host distribution and the environmental niche of spotted lanternfly. We hope to input the vineyard risk model on the NEWA website from which stakeholders can input their location, the API will interface with Google Earth Engine to pull most recent variables and return estimates for periodically updated risk at fine spatial scale. This tool will serve as an early warning system for NY growers cultivating vulnerable crops as well as state and federal agencies with a vested interest in tracking the establishment of this invasive insect. We propose a new remote sensing modeling approach to build on the SLF distribution data that delivers fine resolution predictions of grower risk to mitigate future damage from SLF and guide the accessibility of information as a decision-making tool.

Technology Transfer Plan:

All observational data of both tree-of-heaven and spotted lanternfly are publicly available. All models will be published in an open-access peer-reviewed journal and the vineyard risk model will be translated into a tool on the NEWA website for grower accessibility to risk assessment based on the most recent findings.

Attachments:

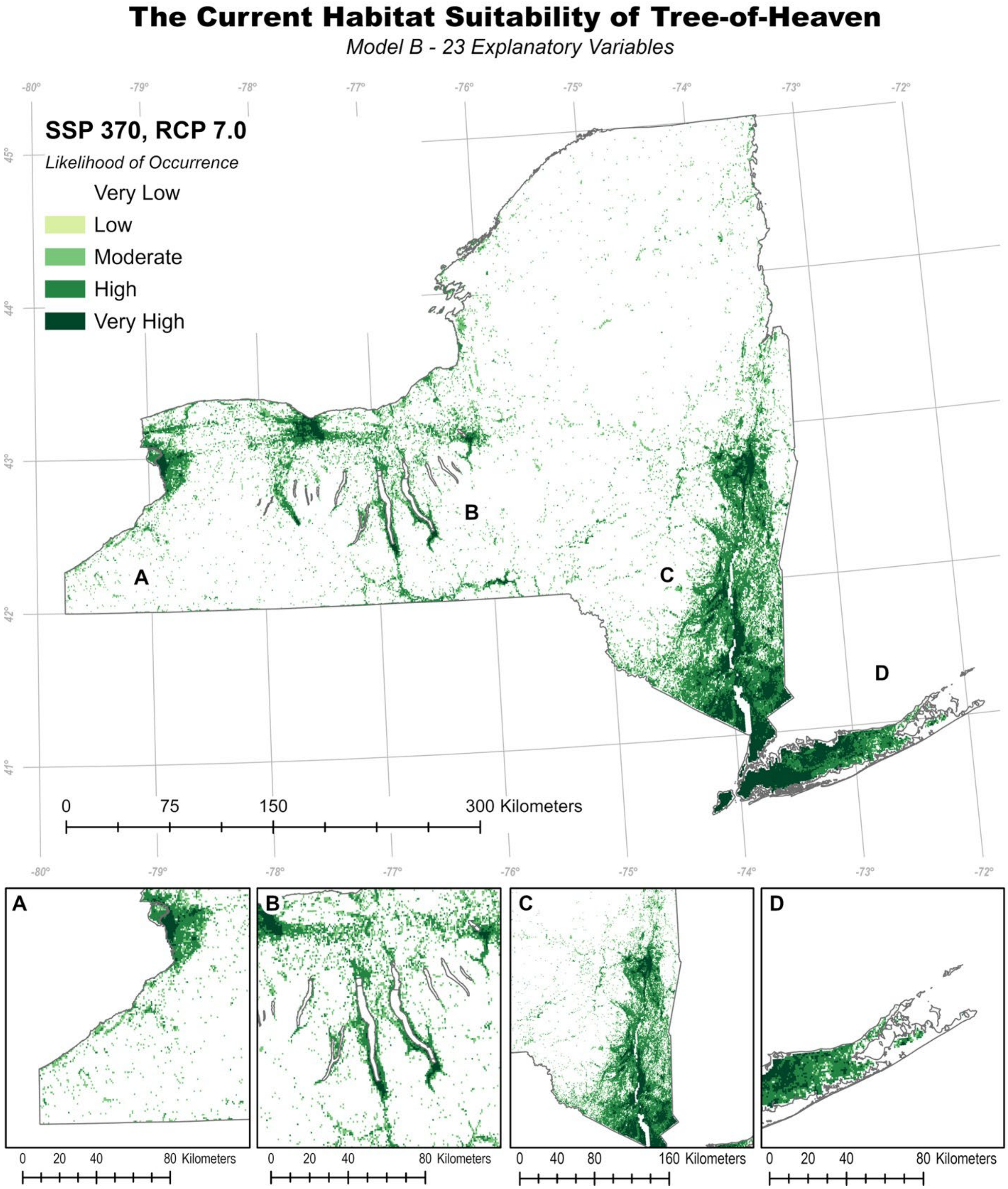


Figure 1: A map illustrating the current statewide habitat suitability for tree-of-heaven in New York State (AUC = 99.90%, TSS = 98.34%, BOYCE = 92.17%), based on 23 explanatory variables. White represents very low likelihood of occurrence, light green represents moderate likelihood of occurrence (≤ 50%), and dark green represents high likelihood (≤ 100%). A statewide view is presented at the top, while (A), (B), (C), and (D) show insets of the zoomed-in regional risk in Lake Erie, Finger Lakes, Hudson valley, and Long Island, respectively.

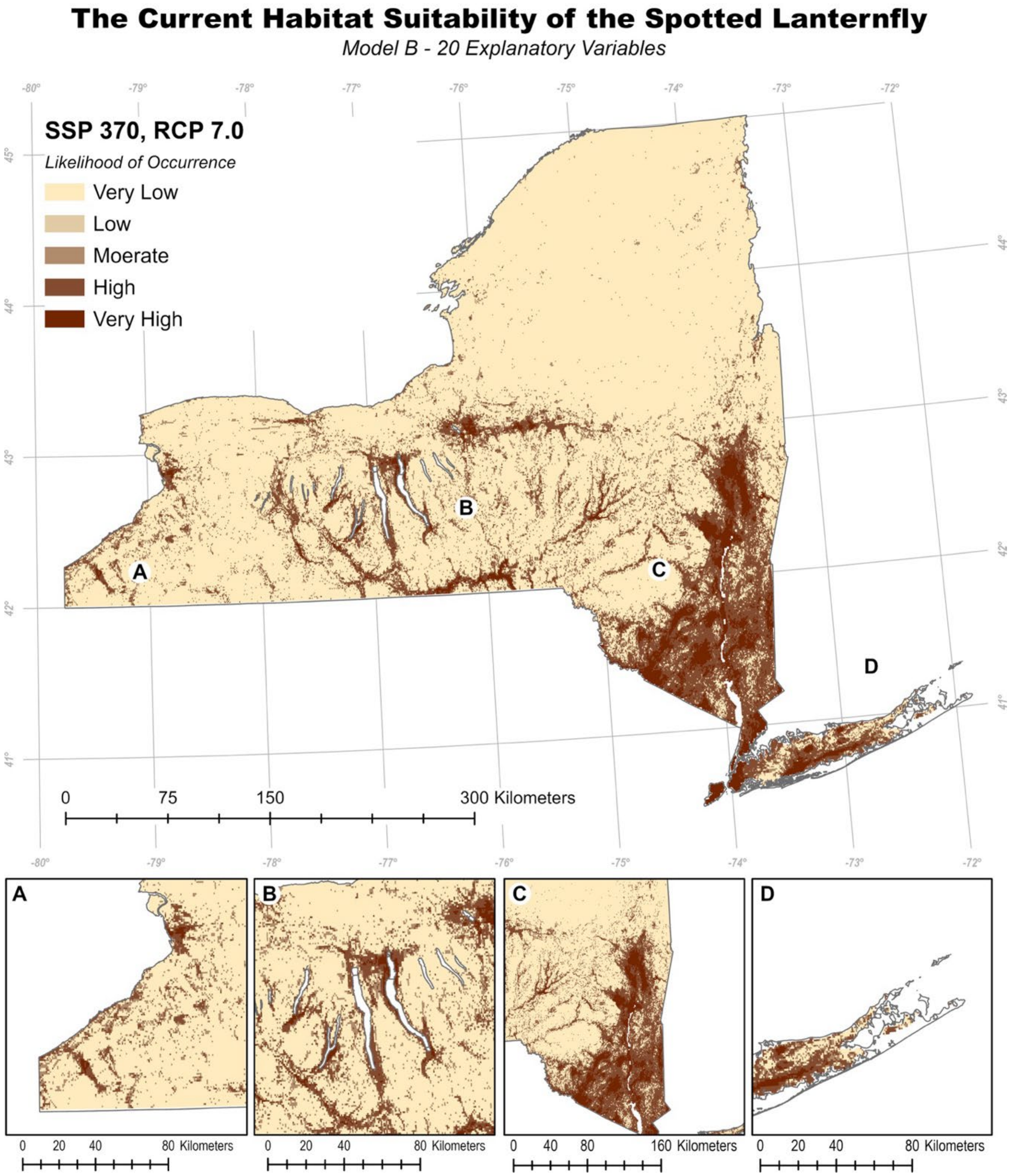


Figure 2: A map illustrating the current statewide habitat suitability for the spotted lanternfly across New York State (AUC = 99.92%, TSS = 98.74%, BOYCE = 91.90%), based on 20 explanatory variables from Model B. A statewide view is presented at the top, while (A), (B), (C), and (D) show insets of the zoomed-in regional suitability in Lake Erie, Finger Lakes, Hudson Valley, and Long Island, respectively. For symbology, Geometric Interval classification was applied, where tan represents very low likelihood of occurrence, Light Brown represents moderate likelihood of occurrence (≤ 50%), and Dark Brown represents very high likelihood (≤ 100%).

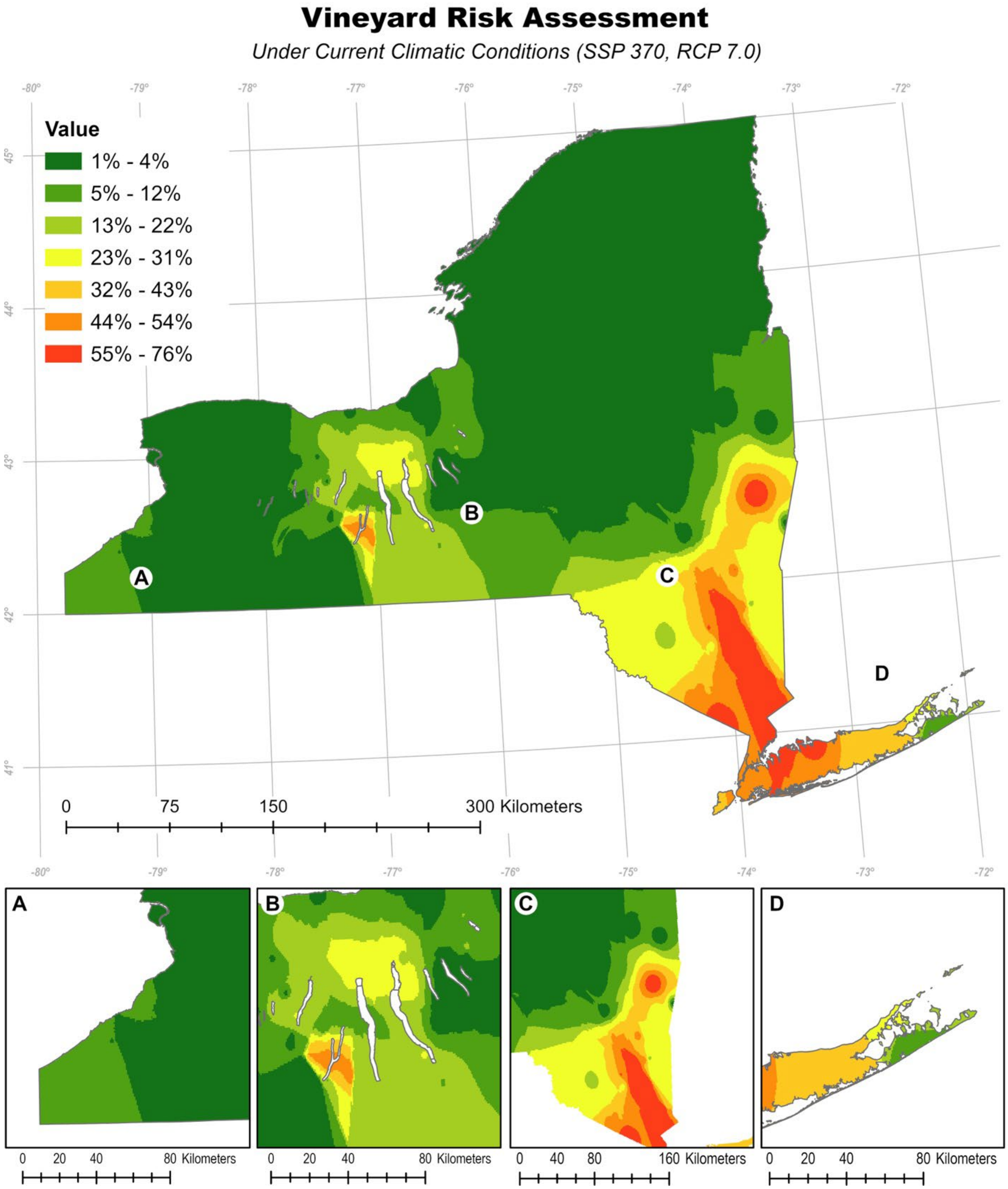


Figure 3: A map illustrating the current vineyard risk across New York State, categorizing regions into different risk zones based on tree-of-heaven and spotted lanternfly interactions and vineyard proximity. A statewide view is presented at the top, while (A), (B), (C), and (D) show insets of the zoomed-in regional suitability in Lake Erie, Finger Lakes, Hudson Valley, and Long Island, respectively. For symbology, a gradient color-scheme was chosen, where Green represents low risk (< 20%), Yellow represents moderate suitability (30-40% respectively), and Red represents high suitability (< 76%).

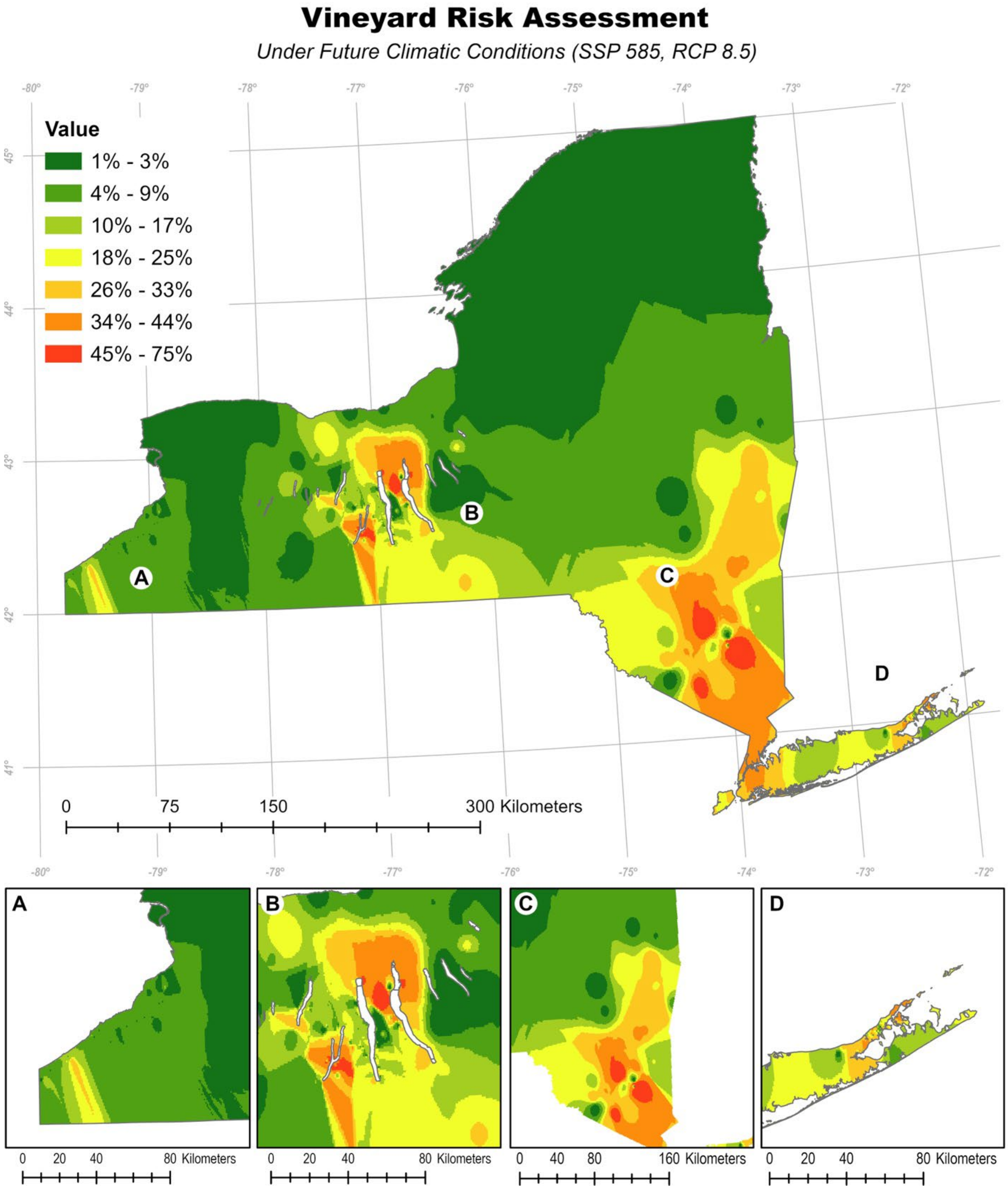


Figure 4: A map illustrating the future vineyard risk across New York State, categorizing regions into different risk zones based on tree-of-heaven and spotted lanternfly interactions and vineyard proximity. A statewide view is presented at the top, while (A), (B), (C), and (D) show insets of the zoomed-in regional suitability in Lake Erie, Finger Lakes, Hudson Valley, and Long Island, respectively. For symbology, a gradient color-scheme was chosen, where Green represents low risk (< 20%), Yellow represents moderate suitability (30-40% respectively), and Red represents high suitability (< 76%).

SECTION 3:

Project summary and objectives:

The aim of this project was to develop risk assessment model for NY vineyards based on habitat suitability of spotted lanternfly and one of its preferred plant hosts, tree-of-heaven. In anticipation of the risk to New Yorks grape growing industry, the New York State Department of Agriculture and Markets initiated a statewide spotted lanternfly monitoring effort in 2020 that has since collected over 10,000 observations of spotted lanternfly and ~10,000 of tree-of-heaven. iNaturalist observations provide an important additional dataset of 10,000 observations tree-of-heaven across New York State. We created habitat suitability models to establish statistical relationships between a species' current geographic distribution and relevant climatic parameters, to predict potential spread which can then be used for landscape and regional risk assessment. Using the spotted lanternfly and tree-of-heaven habitat suitability models we quantified the risk spotted lanternfly poses to the New York wine and grape industry using tree-of-heaven suitability, spotted lanternfly suitability and vineyard density across the state.

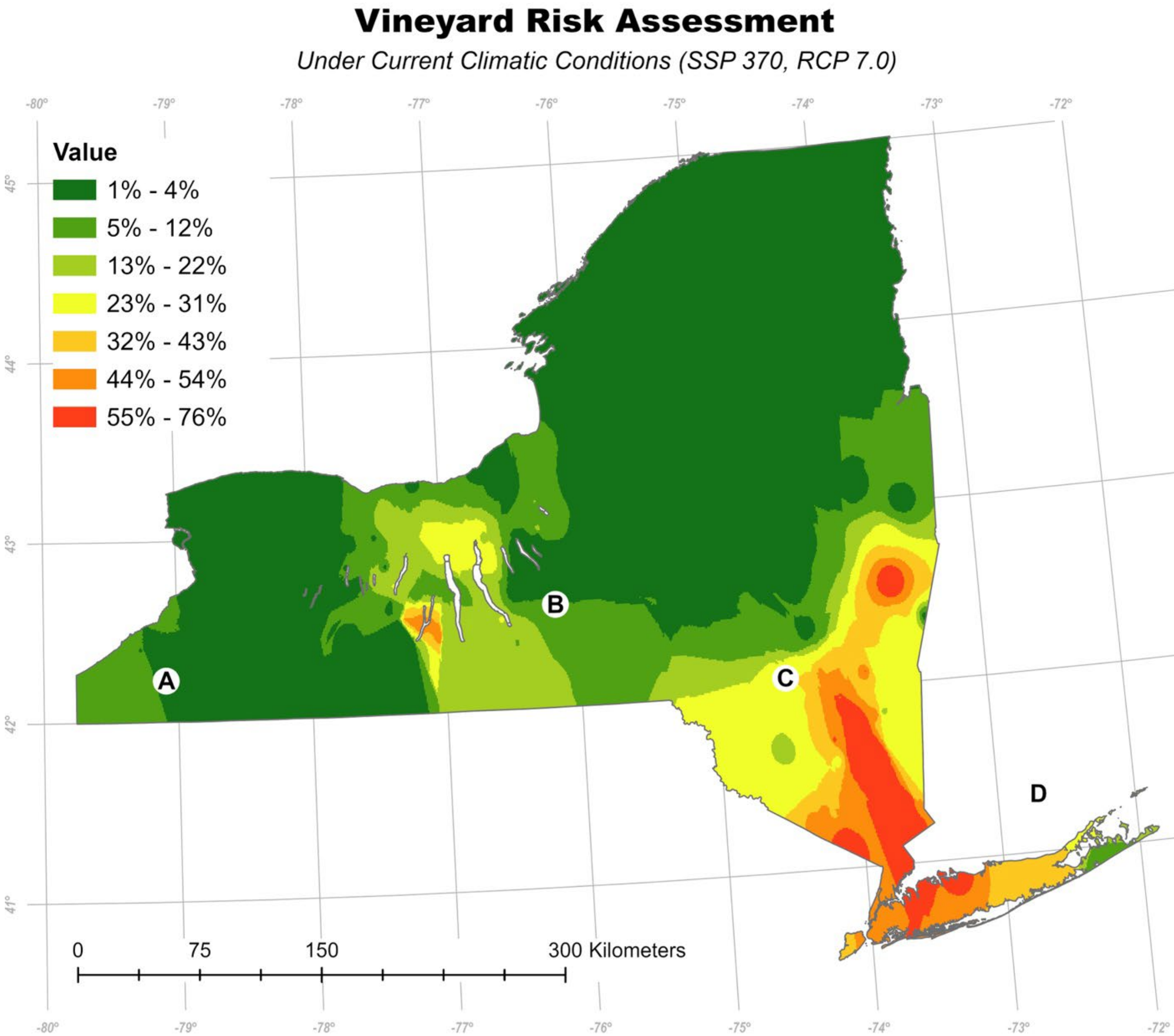
Importance of research to the NY wine industry:

The invasive spotted lanternfly is both an economic threat and useful system for modeling invasive species dynamics and how climate change may drive shifts in distribution. Here, we combined tree-of-heaven index in a spotted lanternfly species distribution model and incorporated climate projection modeling to quantify the current and future risk spotted lanternfly poses to the New York wine and grape industry. Modeling the distribution of the spotted lanternfly under current conditions, both temperature and precipitation play key roles in defining habitat suitability across New York State. Our analysis revealed that incorporating a tree-of-heaven index is equally as important as including a human influence index when modeling spotted lanternfly habitat suitability. The wine and grape growing regions in New York State that are currently classified as moderate risk, particularly in the Finger Lakes, Hudson Valley, and Long Island regions, are projected to experienced increased risk in the future. Vineyard areas identified to be at higher risk should increase scheduled monitoring efforts.

Project Results/next steps:

There was a critical need for spatiotemporal machine-learning modeling that incorporates preferred plant host distribution and the environmental niche of spotted lanternfly. We hope to input the vineyard risk model on the NEWA website from which stakeholders can input their location, the API will interface with Google Earth Engine to pull most recent variables and return estimates for periodically updated risk at fine spatial scale. This tool will serve as an early warning system for NY growers cultivating vulnerable crops as well as state and federal agencies with a vested interest in tracking the establishment of this invasive insect. We propose a new remote sensing modeling approach to build on the SLF distribution data that delivers fine resolution predictions of grower risk to mitigate future damage from SLF and guide the accessibility of information as a decision-making tool.

Supporting attachments:



Supporting Figure: A map illustrating the current vineyard risk across New York State, categorizing regions into different risk zones based on tree-of-heaven and spotted lanternfly interactions and vineyard proximity. A statewide view is presented at the top, while (A), (B), (C), and (D) show the regional suitability in Lake Erie, Finger Lakes, Hudson Valley, and Long Island, respectively. For symbology, a gradient color-scheme was chosen, where Green represents low risk (< 20%), Yellow represents moderate suitability (30-40% respectively), and Red represents high suitability (< 76%).