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Tree-Caused Power Outage Prediction Model

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September 30, 2022

Agenda

- Company Background
- Project Overview
- Data Collection
- GIS Display Tool Architecture
- Model Validation
- Q & A

About Us

$45B	6M+	24K	65K	$26B	12K
Total Assets	Total Customers in Five States	Transmission Miles	Square Miles of Service Territory	2022F Rate Base	Employees

Digital Transformation Initiative → **Investment in Advanced Analytics**

Project Challenge Statement & Value

Identified various advanced analytics opportunities in Forestry area via Design Thinking, determined the below could yield the most value

The Challenge

***How might we** predict potential occurrences of distribution tree-caused outages based on physical and environmental impacts, **so that** we can make data-driven vegetation management decisions to maximize investment value.*

The Value

This tool aims to achieve a net improvement in reliability metrics as they relate to tree-caused outages. Model output, coupled with proper preventative maintenance action could:

- Reduce number of tree-caused outages
- Reduce revenue impact of tree-caused outages
- Improve utility reliability metrics
- Improve customer satisfaction

Use Cases

Forestry Manager

Forestry Specialist

The below applications were defined through user research sessions with FirstEnergy Forestry professionals

Use Case 1

DATA-DRIVEN MAPPING TO SUPPORT CONTRACTOR COLLABORATION

- Pull dashboard insights and data points to enhance physical GIS maps used in the field
- Support Forester conversations and work activity prioritization with contractor crews

Use Case 2

RISK PREDICTION TO GUIDE WORK ACTIVITIES

- Prioritize high-risk areas when planning scheduled trimming activities
- Identify high-impact circuits to allocate unexpected funds

Use Case 3

YEARLY BUDGET PLANNING

- Support budget proposals for yearly budget planning meetings
- Enhance work planning estimates (e.g., estimated cost per mile, trees per mile, etc.)

Frequent Application — ***Frequency of Application*** — *Less-Frequent Application*

Model Approach

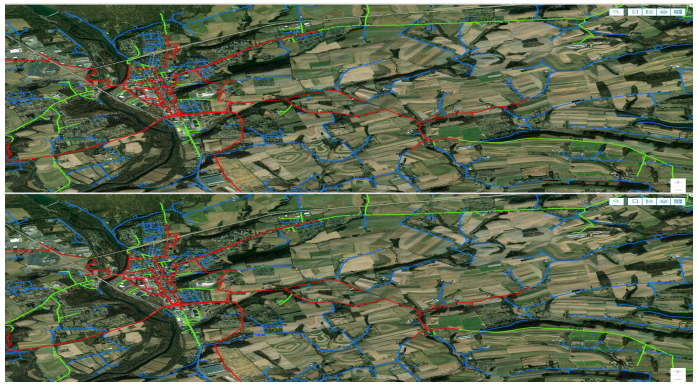
Through additional user research sessions, the team decided on the main components of the tool

1. **Data Pipeline**

2. **Machine Learning Modeling**

3. **Data Visualization**

End-users consume model output in an easy to navigate mapping tool

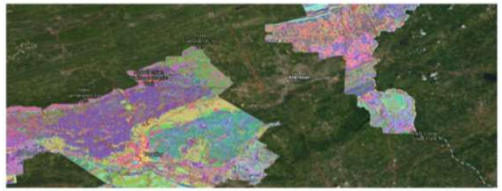


Datasets and Sourcing

Externally-Sourced

[1]**FIADB:** Tree population and species estimates by county

[2]**gSSURGO:** Soil information at sub-city scale



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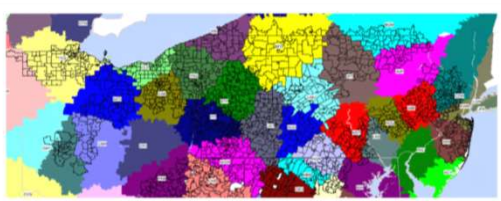
[4]**NOAA:** Detailed hourly weather



Internally-Sourced

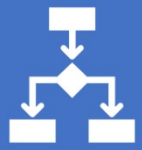
Vegetation Mgmt System:
Tree maintenance program information

Outage Mgmt System:
Tree-caused outage information

GIS Circuit:
Asset location and identification information

Datasets and Sourcing

Model Overview



Random Forest: Supervised learning model which identifies patterns within feature variables using decision tree methodology
(see right for sample feature list)

Model Output

Model calculates a numerically-represented **likelihood** of a tree-caused outage on a particular span of distribution wire.

Likelihood is then multiplied by **# of customers** downstream.

Sample of Features

1. Slope
2. Length of Wire
3. Elevation
4. Average Pole Age
5. Aspect
6. Frost Free Days
7. Average Air Temperature
8. Mean Annual Precipitation
9. Albedo
10. Total Annual Precipitation

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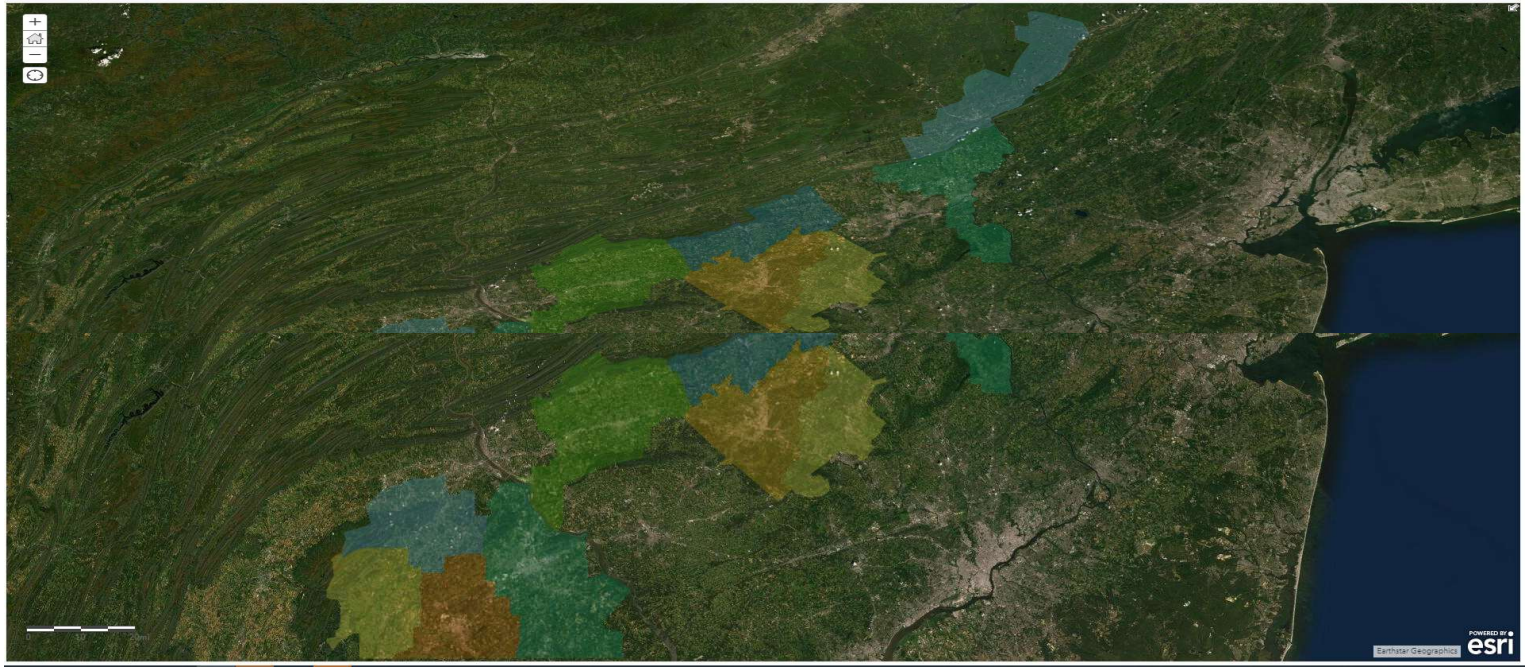
Tool

Tool Preview

Leverages FirstEnergy's enterprise ArcGIS license, which enables easy consumption and sharing of layers and dashboards across the organization



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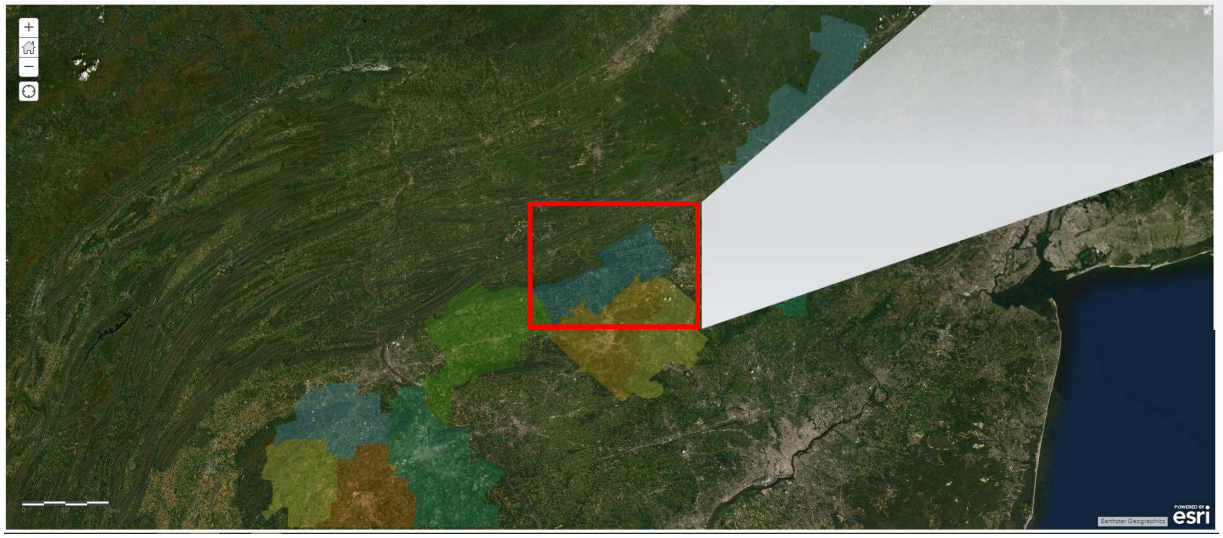
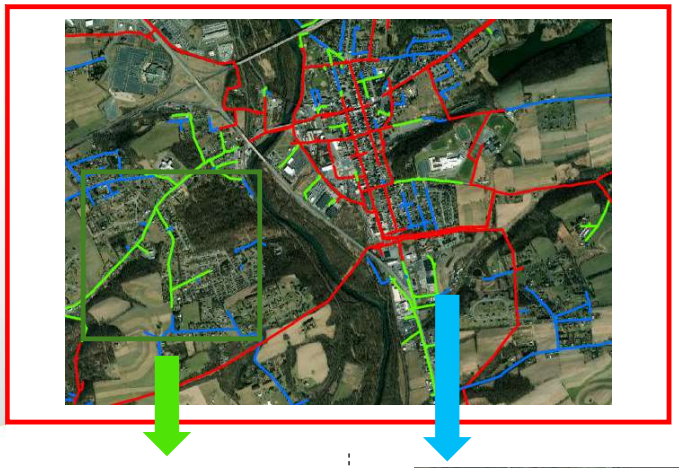
Tool Preview *(cont'd)*

Zooming in populates more granular details in layers:
- Distribution line data (GIS)
- Outage investigation (VGMS)



Distribution circuits are color-coded by zone



Selecting a **wire** or **outage investigation** initiates a pop-up w/ detailed info

Tool Preview *(cont'd)*

Zooming in further populates more granular details in the selected layers (Faultable devices, Poles, Tree-caused outages)

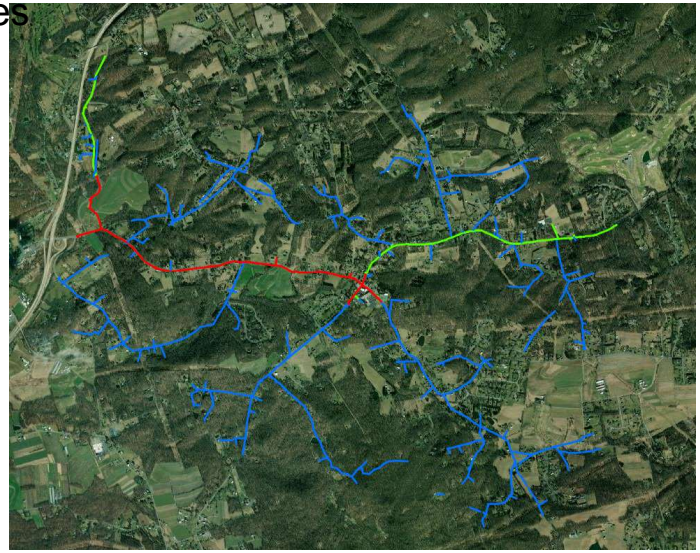
Devices are coded by shape

Selecting a **red pole** initiates a pop-up with detailed info related to a tree-caused outage, while selecting **tan pole** brings up its location and detailed info related to the local earth characteristics

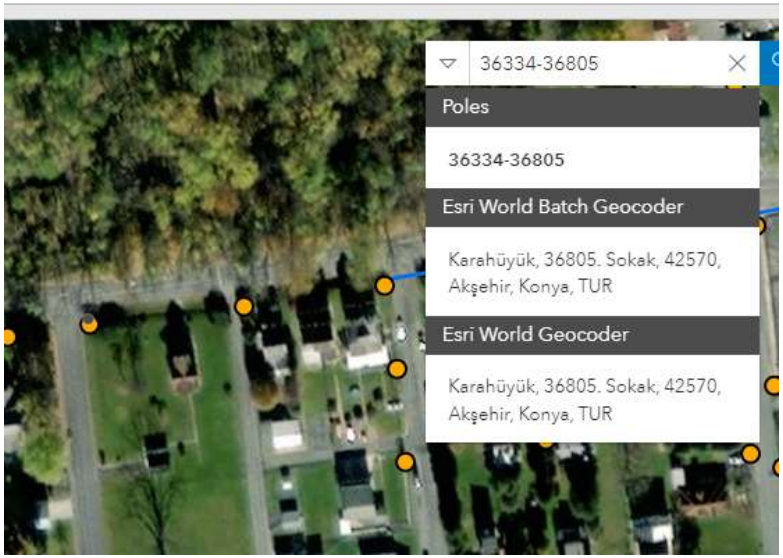
Tool Preview *(cont'd)*

Intuitive search and filtering capabilities

By Circuit: After a Circuit Name or ID is selected, the tool navigates to its location and highlights the related features

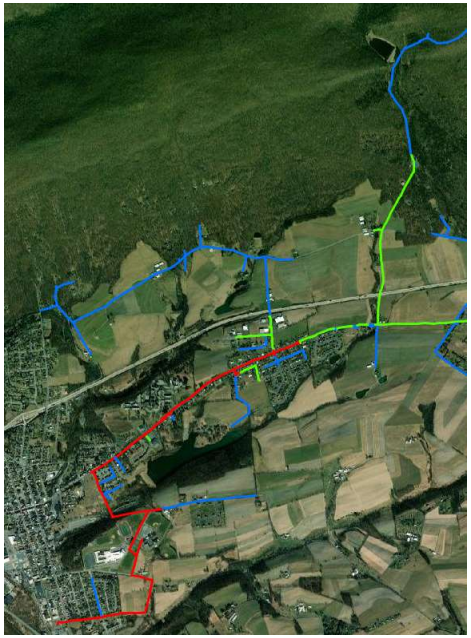


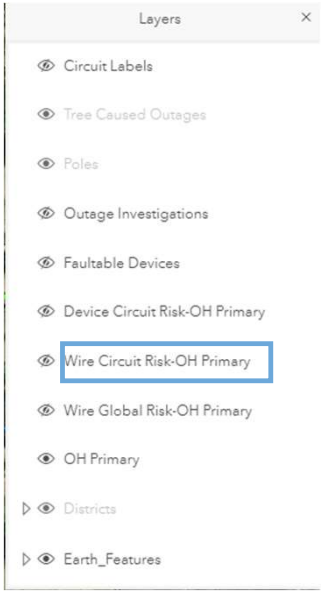
By Pole: Similarly, poles can be searched, and the tool will navigate and highlight it

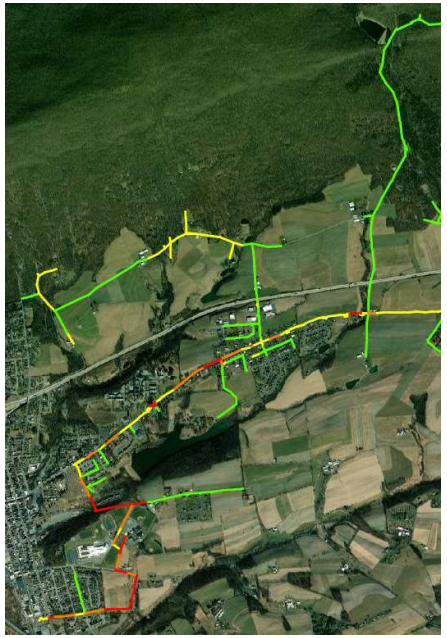


Tool Preview *(cont'd)*

Visualization of predictive risk model







The wires are color-coded by calculated risk level

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Model Validation

Retroactively applied the model to 2018 trimming cycle

Model identified the following:

914 Outages → **145k** Customers Impacted

(From 2018-2021)

A/B Testing phase began January 1, 2022, with eastern-PA operating company

Target wire spans with the highest predicted **likelihood** of having a tree-caused outage based on model output

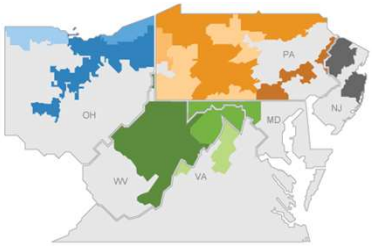
Split 2022 circuits into A & B pairs based on comparable features

Group A *(baseline/control)*
Group B *(tool-enhanced)*

Potential Enhancements

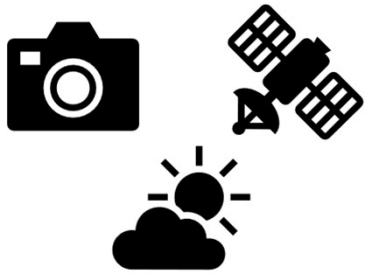
Scale to remaining footprint

- Expand internal and external dataset scope
- Explore environmental differences across remaining operating companies and potential impacts on model



***Future release possibilities**

- Incorporate satellite imagery and/or LiDAR data
- Expand historical weather capabilities



**Dependent on A/B Testing results*

"With the click of a mouse, we can see the probability of outages, and this model can take us right down to the pole level. It's exciting to think of how we can use this to minimize storm impacts over time and ensure reliability for our customers " - **Doug Kinyo *(Manager, Forestry Services)***

Acknowledgements

FirstEnergy

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accenture

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- Tamara Cody, Designer

USGS science for a changing world

USDA

Forest Service U.S. Department of Agriculture

NOAA

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Q&A

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Appendix

Datasets and Sourcing

Per mtg with UA - Want to make sure we hit about the full data collection process

Externally-Sourced

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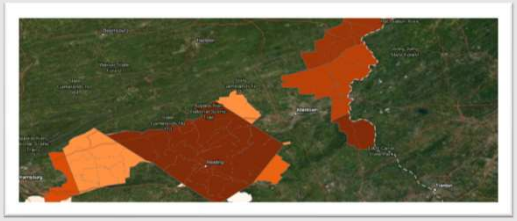

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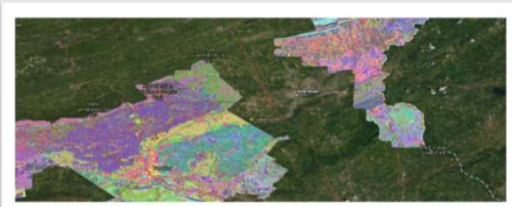

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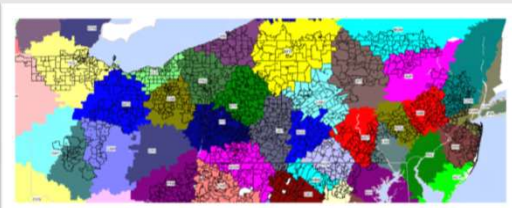

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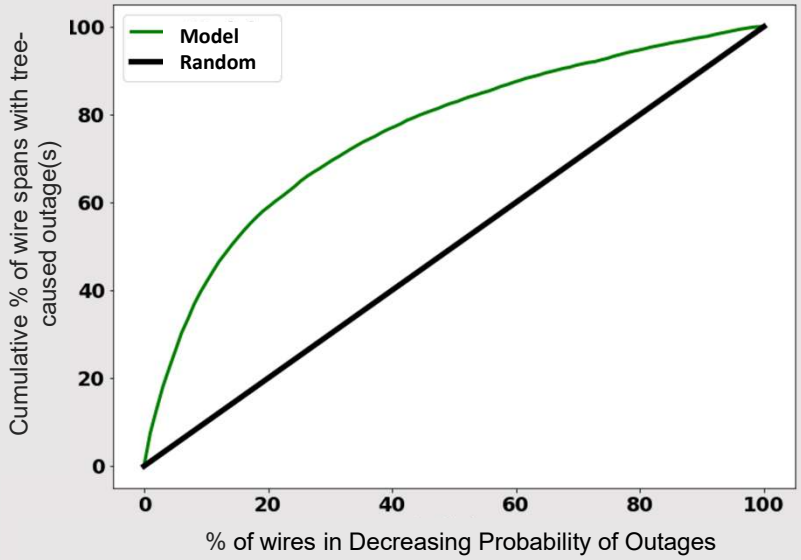
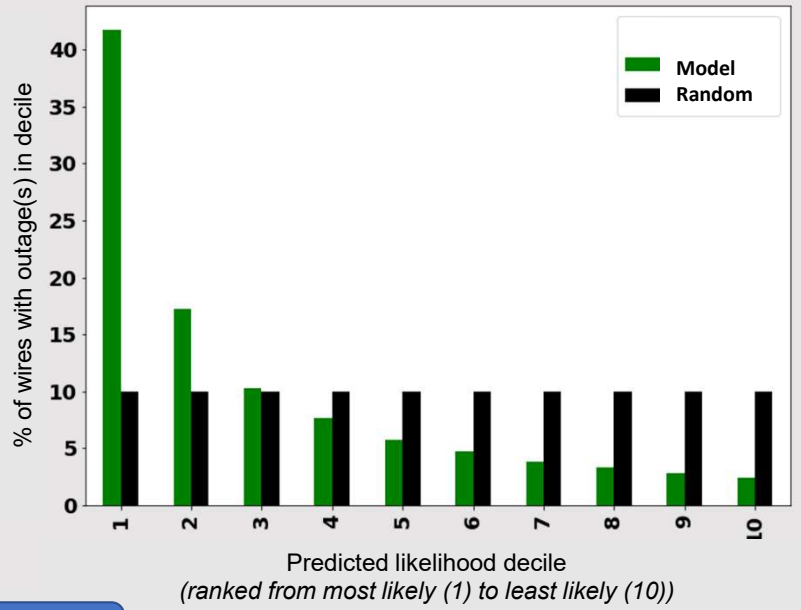
Predictive Model Performance

Too in the weeds? Move to appendix

Final Predictive Model: Random Forest using Python imbalanced learn package





F1 Score: Assuming 1st decile is targeted as true positive = 0.51

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