

WISPR

Wind Impact Study for Power Resilience

A DOE GRACI-funded collaboration advancing climate-resilient grid planning through industry, utility, and academic partnership

Consortium

Technology Partner
(Lead)

Greg Itzstein
Pointerra

Utility Partners

Daniel Stevens
National Grid
(representing all utilities on the program)

Academia Partners

Zongjie Wang | Colorado State University
Anna Scaglione | Cornell University
Jan Woodcock | University at Albany

Funded by: **U.S. Department of Energy – GRACI Program** | Grant: \$1.63M | Timeline: June 2024 – October 2025

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Study Introduction

Consortium Overview & The Case for Collaboration



Greg Itzstein

Pointerra – Program Lead

The Challenge: Climate Risk & Grid Resilience

Vegetation outages are the #1 driver of power interruptions in the Northeast

Historically, utilities relied on **fixed-cycle trimming** — not risk-informed targeting

Climate change is driving higher-frequency, higher-intensity wind events through 2050

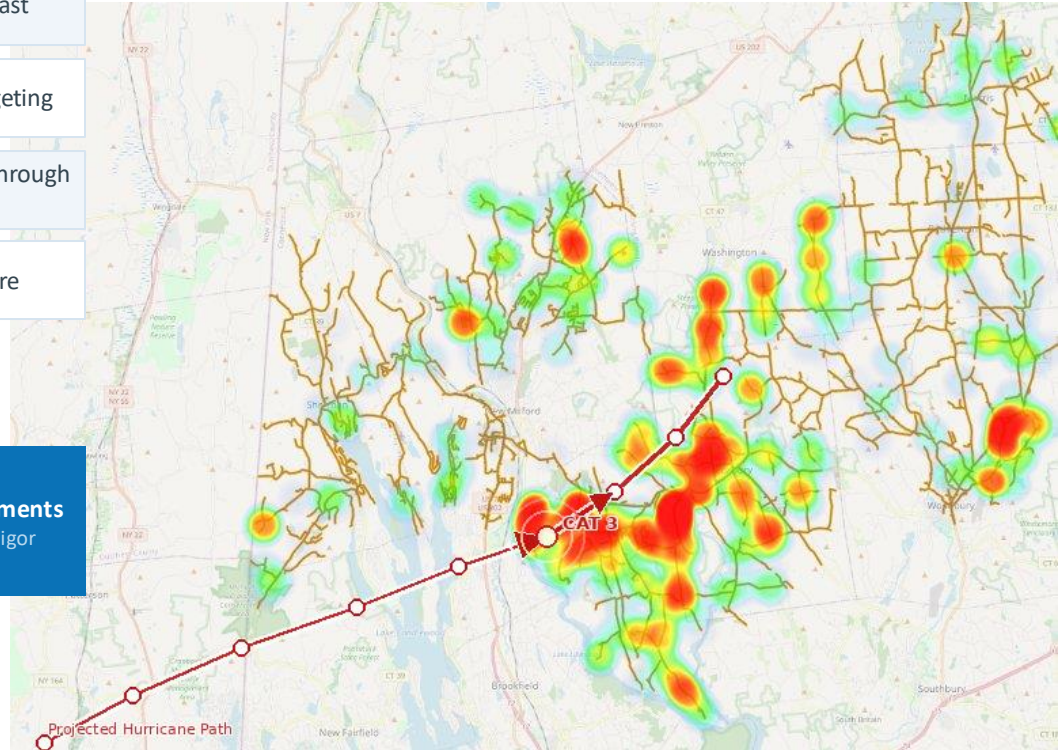
Utilities face rising **O&M costs**, aging infrastructure, and regulatory pressure

UTILITIES ARE MOVING TOWARD DATA-DRIVEN FRAMEWORKS TO

Quantify outage risk
at tree and span level

Project risk
under future climate
scenarios

Prioritize investments
with economic rigor



DOE GRID RESILIENCE & CLIMATE CHANGE IMPACTS (GRACI)

Program	Launched January 2024 — funds cross-sector consortia to assess regional climate threats on grid infrastructure
Grant	\$1.63M awarded — initiated by National Grid, submitted by Pointerra3D
Objective	Explore data driven predictive risk prioritization for operating a wind-resilient grid in the U.S. Northeast
Timeline	June 2024 – October 2025 7 Milestones

CONSORTIUM: INDUSTRY + UTILITY + ACADEMIA

Technology Lead	Utility Partners
Pointerra Deployment of Pointerra3D platform for high resolution lidar processing, vegetation risk screening, and CDE	National Grid · Supporting Utility Partners Circuit access, outage data, and operational expertise across MA, NY, ME and CT
ML Outage Model	Tree Risk Model
University of Connecticut ML outage prediction using weather forecasts, outage history & vegetation indices	Cornell University Physics-based Hybrid Tree Risk Model using LiDAR point clouds and biomechanical failure thresholds
Climate Modeling	Optimization Framework
University at Albany, SUNY WRF downscaling & Thermodynamic Global Warming scenarios for high-res climate projections	Cornell & Colorado State Univ. Optimal Vegetation Management Framework — integrates risk, cost and budget constraints

High-Resolution LiDAR feeding physics-based tree modeling

- Mobile Laser Scanning over 10 circuits — maps tree morphology, span geometry, pole lean, and clearance
- Per-tree height, crown width, and lean angle supply the biomechanical inputs Cornell's Hybrid Tree Risk Model uses to compute failure probability under wind loading

Historical Outage Intelligence feeding outage forecasting

- Decade-long outage records at span level to reveal failure patterns
- Span-level outage history across utility circuits trained UConn's ML model to learn relationships between wind speed, vegetation density, and outage likelihood — producing forecasts under current and future storm scenarios

Climate-Informed Wind Projections feeding risk prioritization

- Weather research and forecasting (WRF) downscaling + Thermodynamic Global Warming framework projects storm intensities through mid-century
- Albany's WRF wind speed and direction forecasts allow risk scores to be assigned directionally at span level, prioritising trees and poles most exposed to dominant wind vectors

Economic Optimization Models feeding resiliency strategy

- Cost optimization framework ranks tree cutting, pole raising, and undergrounding by resilience return per dollar
- By combining span-level risk scores, climate projections, and unit costs, the optimizer produces a ranked investment roadmap — moving utilities from fixed-cycle maintenance toward risk-prioritised capital allocation

Utility Perspective

Why WISPR? Operational Drivers & Circuit Selection



Daniel Stevens

National Grid

Operational reality

- **Vegetation-caused outages is a leading cause of customer interruptions.**
- Veg. mgmt. is often one of the **highest O&M expenses**.
- The requirements for veg. mgmt. are often informed by state regulations and commonly rely on a **fixed cycle-based schedules**.
- When risk models are used, they are often informed by **historical data and there are limitations** on modifying veg. mgmt. practices.

Strategic imperative

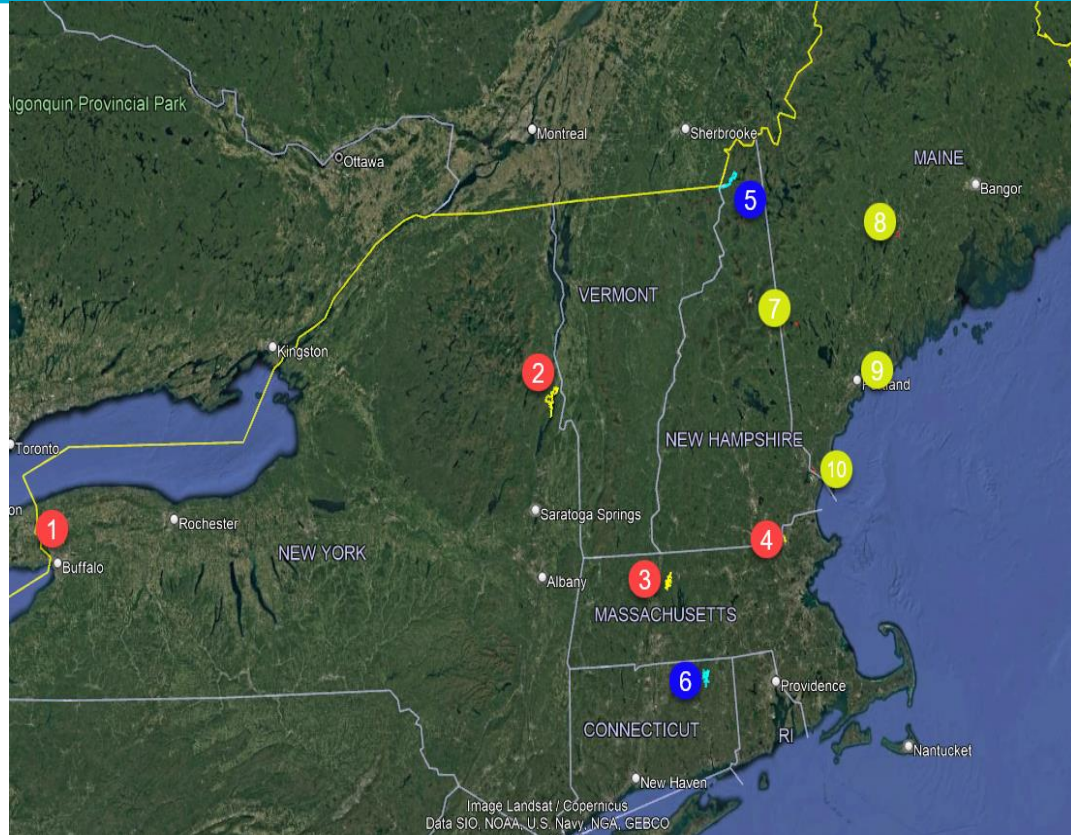
- **Customer expectations around reliability have grown, as have storm frequency and intensity.**
- Utilities recognize the importance of making smart, **risk-informed decisions** to maximize climate mitigation against costs.
- **Grid modernization and resiliency plans** require defensible, data-driven investment justification.
- Regulatory filings (NY, MA Climate Resilience Action Plans) demand evidence-based mitigation strategies.

Innovation opportunity

- LiDAR and digital twin technology had not been coupled with physics-based tree risk and climate modeling at scale — WISPR represented a chance to develop an industry-leading analytic framework with DOE funding.
- Aligns with National Grid's Future Grid Plan: building a smarter, stronger, cleaner, and more equitable energy future.
- However, we need to recognize this is the beginning. Additional data, such as asset health and a localized understanding of risk-informed impacts, along with a wider range of mitigation strategies is needed.

National Grid and partner utilities selected 10 circuits across New York, Massachusetts, Maine and Connecticut to ensure:

- Low historical reliability performance.
- Varied population density — from dense urban to deeply rural, including EJs¹.
- Diverse vegetation constraints — heavily forested vs. mixed terrain.
- Range of customer profiles — residential, commercial, and critical load scenarios.



¹An **EJC (Environmental Justice Community)** generally refers to a geographic area where residents face **higher environmental burdens and socioeconomic vulnerability**

What Industry Brings

- Operational data: outage records, GIS assets, circuit performance.
- Insights on real-world constraints: environmental permits, community approvals.
- Potential to scale deployment: tens of thousands of miles of network.
- Understanding the regulatory context and investment approval processes.

What Academia Brings

- Physics-based modeling rigor - biomechanics, fluid dynamics, statistics.
- Machine learning innovation beyond typical utility analytics.
- Climate science expertise.
- Peer-reviewed validation and publication credibility.

What Technology Brings

- High-resolution 3D data collection and processing at scale.
- Cloud-hosted digital twin platform unifying all data sources.
- AI-driven asset and vegetation segmentation automation.
- Scalable framework for utility-wide deployment.

Together: a unified framework that no single sector could have established alone

LiDAR Collection & Digital Twin Processing

Milestone 3: Creating the Data Foundation

Greg Itzstein

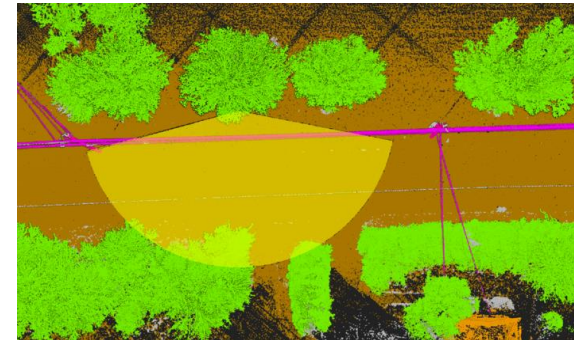
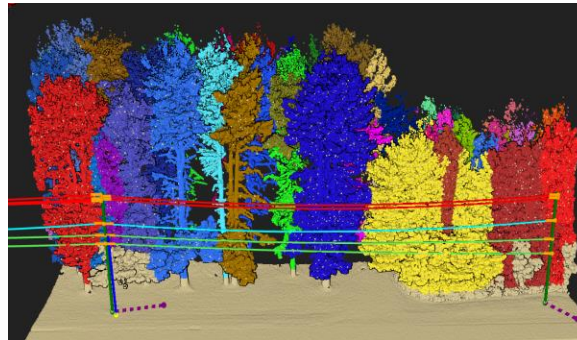
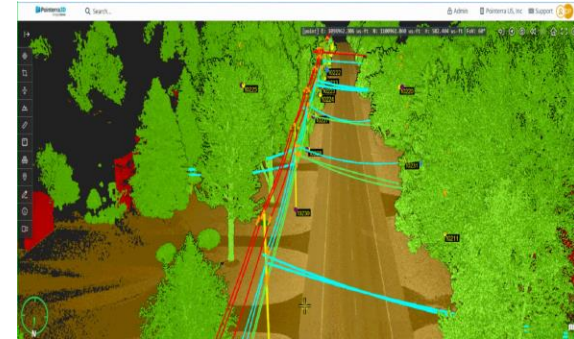
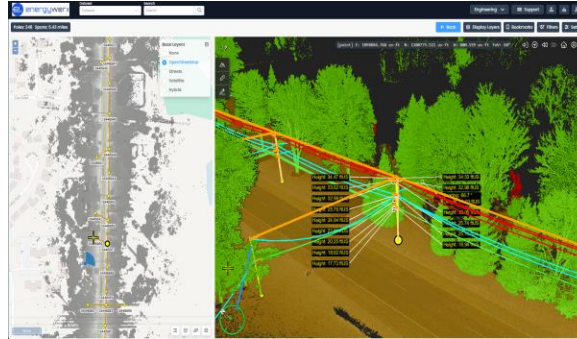
Pointerra – Program Lead

Mobile Laser Scanning at Scale

- 10 circuits across MA, NY, ME — National Grid and Avangrid territories
- Vehicle-mounted LiDAR capturing dense 3D point clouds at road speed; centimeter-level resolution of every tree, pole, wire, and structure
- Per-tree geometry: height, DBH, crown area, proximity to conductors

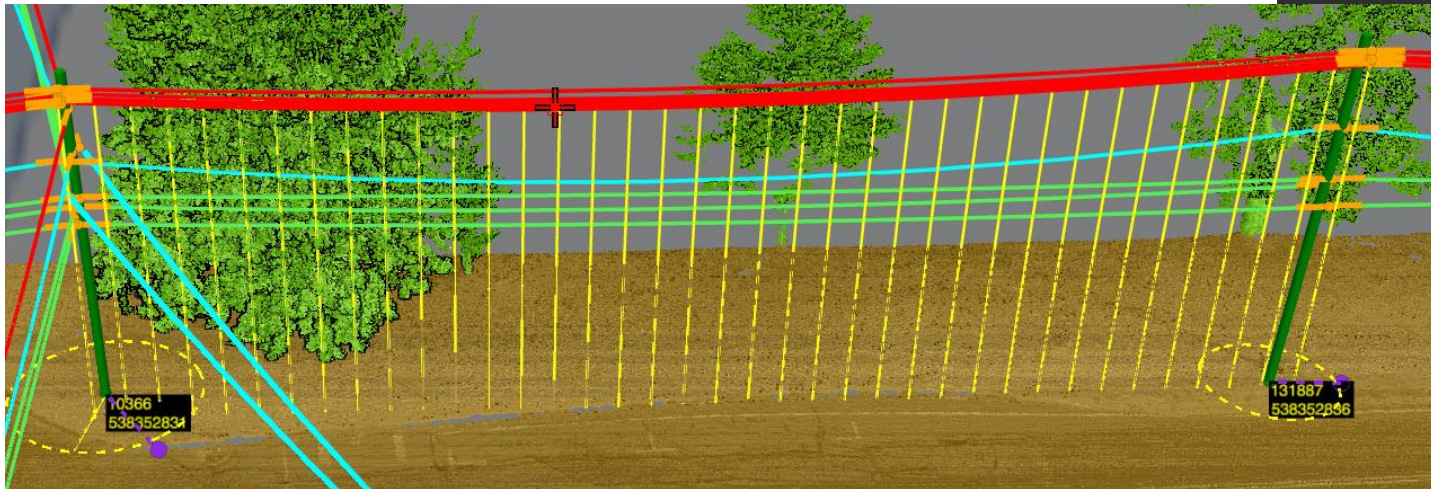
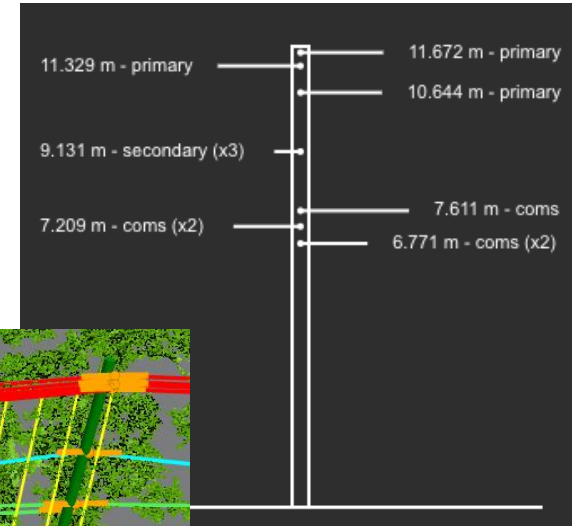
Pointerra3D Digital Twin Platform

- AWS-hosted common data environment accessible by all consortium partners
- Automated asset extraction: poles, wires, spans — no manual digitization
- Individual trees segmented and attributed with height, crown geometry, hazard features, and strike interaction potential
- Per-span risk screening feeds Cornell and UConn downstream models



Beyond WISPR — the digital twin is not one dimensional and enables utility resiliency planning at the asset level independent of wind-related outage predictions

- Asset condition monitoring
- Clearance analysis
- Attachment spacing audits
- Joint use surveys
- Vegetation encroachment tracking
- Pole lean & sag trending



Outage Prediction & Tree Risk Modeling

ML Models, Physics & Climate

Zongjie Wang/Anna Scaglione/Jan Woodcock

Colorado State University/Cornell University/University at Albany

ML Outage Model

- 10-year historical dataset (2014–2024); inputs: wind speed/direction, snow type, vegetation index
 - Transformer-based architecture with cyclic wind encoding and seasonal patterns
- **AUC = 0.783** — strong outage/non-outage discrimination

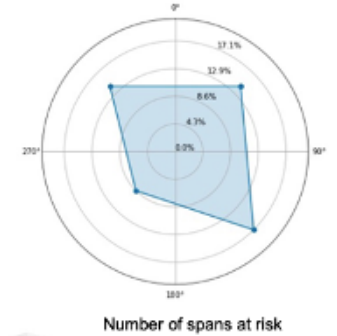
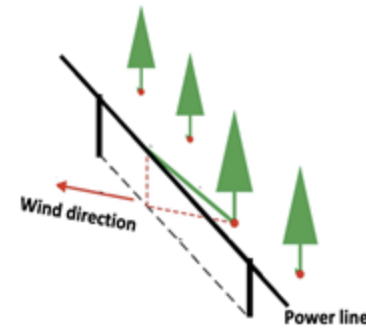
Physics-Based Tree Failure Model

- LiDAR-extracted DBH, height, and crown area feed biomechanical failure model
 - Two failure modes: uprooting (lower winds) and stem breakage; Critical Wind Speed per tree ~15–25 m/s
- **Span-level probabilities validated against historical outage records**

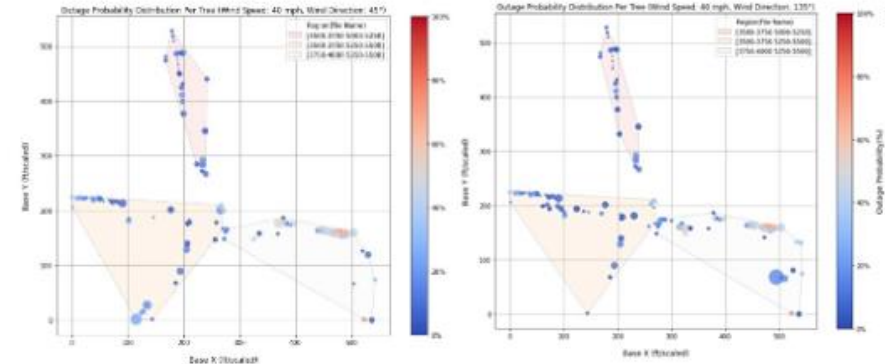
Key Findings

Based on the parameters of this study

- Sustained high winds (not gusts) are the primary outage driver;
- 260–360° and 0–20° show highest frequency of outages
- Wind fields merged with circuit topology for per-tree wind load assignment
- Seasonal variability and directional exposure fully modeled — validated on Circuit A (MA), generalizes across 9 circuits.



Impact of wind direction on individual tree-induced outage probability (fixed 40mph, 45° ~ 315°)



(a) condition: 40mph, 45°

(b) condition: 40mph, 135°

TGW Climate Framework

- Thermodynamic Global Warming: historical events ‘replayed’ under CMIP6 warmer conditions
- WRF dynamic downscaling to circuit level; validated against weather station observations
- Improved RMSE vs. uncorrected output

Mid-Century Wind Projections

- RCP 8.5 (2055–2059 vs. 2015–2019): Hurricane Sandy-type gusts up +10 MPH
- Up to 10 more days/year exceeding 100 MPH; 30 more above 60 MPH
- Winter (Dec–Apr) most affected; NY State sees greatest increase across all territories

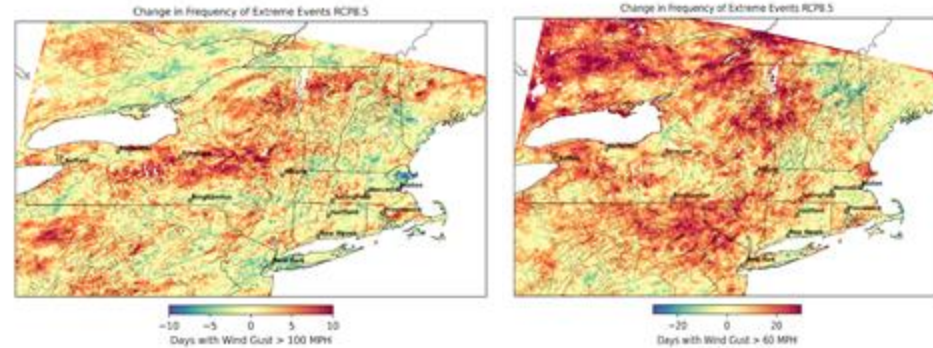
→ Climate signals are actionable: adjust investment strategy before risk materialises

Integrated Risk Pipeline

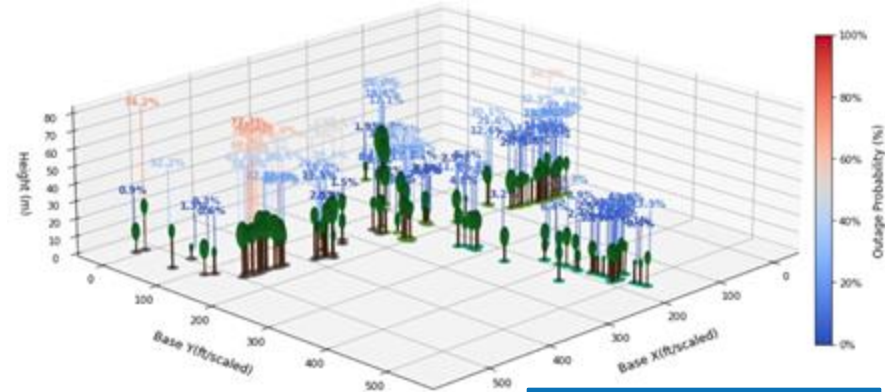
- Downscaled wind fields fused with per-tree LiDAR metrics
- Canopy attenuation and vertical wind scaling incorporated
- Outputs: span and cell-level risk indicators under current and future scenarios

Circuit-Level Validation

- High-density circuits (>500 trees/mile) show strongest correlation with projected outage increase
- Circuit A (MA) and Circuit B (NY) show highest climate sensitivity
- Low-density circuits show minimal incremental risk — investment not warranted



Different wind directions lead to varying sets of hazardous trees, their respective counts, and the resulting tree-induced outage probability.



Cost Benefit Analysis & Study Outcomes

Resiliency Mitigation Framework

Zongjie Wang

Colorado State University

Optimization Framework

- Submodular, budget-aware greedy approximation algorithm
- Allocates spending across spans by marginal resilience return per dollar invested
- Three mitigation strategies: tree cutting (~\$400/tree), pole elevation (\$30K–\$70K/span), undergrounding (\$50K–\$200K/span)
- Life-cycle cost analysis using present-value calculations for fair multi-decade comparison

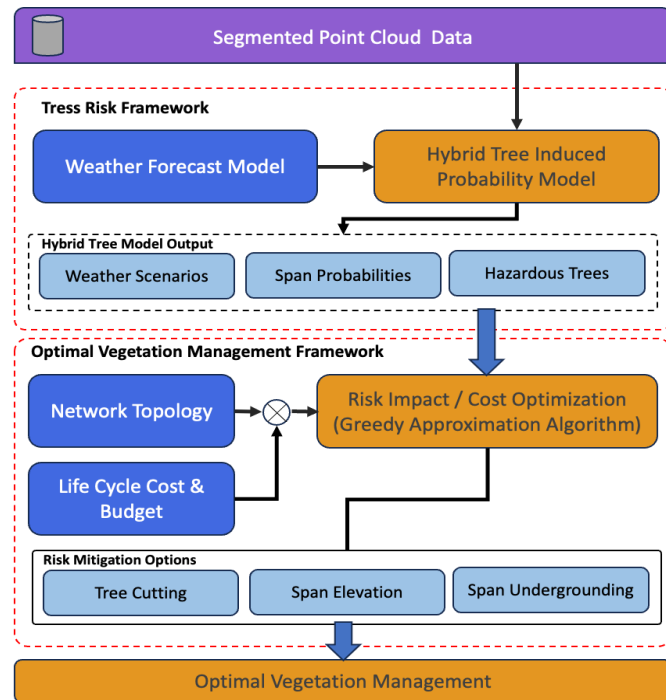
→ Produces a ranked investment roadmap — the ‘efficient frontier’ of resilience vs. spend

Circuit Cost-Benefit Results

Based on the parameters of this study:

- Circuit A: \$200K investment → \$2.42M avoided outage value — ROI 1,111%
- Circuit D: \$20K → \$486K avoided — ROI 2,332%
- Circuit G: \$50K → \$11.38M avoided — ROI 22,661%
- Low-density circuits (B/E/H/I): negative ROI — fixed-cycle trimming not warranted

→ High trees-per-mile (>500) circuits deliver the strongest returns



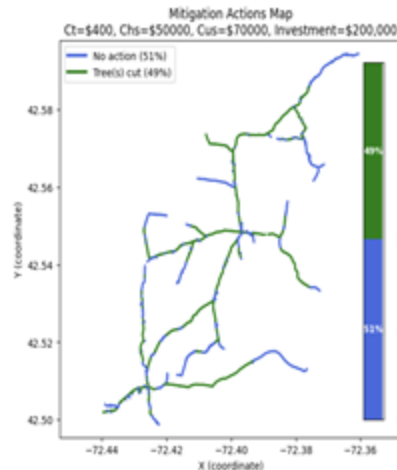
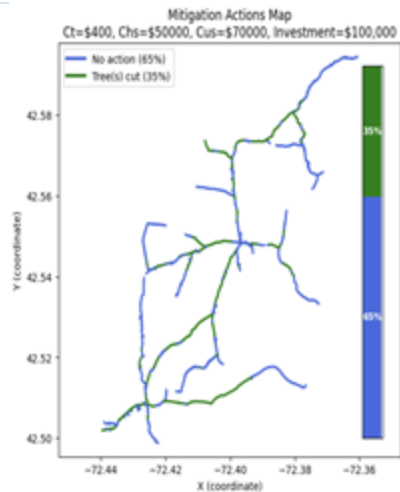
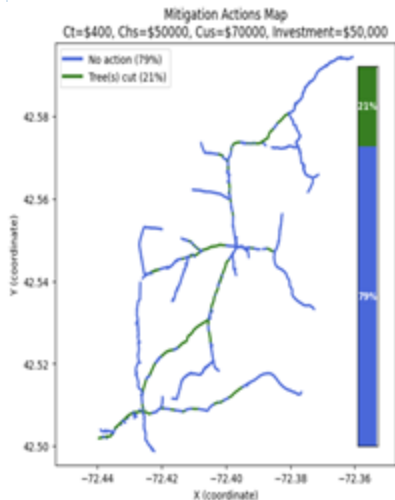
The Investment Sweet Spot

- Most circuits show a 'knee' around \$500K — beyond which marginal returns drop sharply
- Investments of \$100K–\$200K per circuit can substantially reduce outage risk via selective tree cutting
- Aggressive undergrounding rarely justifies cost within wind-hazard scope
- Risk-weighted span ranking vs. fixed-cycle trimming: targeted action is both effective and efficient

Resiliency Strategy Paths

- Targeted vegetation management: BCR >3.0 at low budgets; 40–60% outage reduction at top 10–20% high-risk spans
- Pole raising: 15–25% contact probability reduction during >30 mph events; best in suburban/forest-edge feeders
- Selective undergrounding: near-zero risk; justified only where outage cost > annualised investment
- New Ground Level Distribution tech may shift undergrounding economics

→ A small subset of spans drives the majority of outage risk



Precision beats proximity - WISPR unified data that utilities typically hold in separate systems. Lidar, outage records, GIS circuit topology, customer impact, and unit costs combined into a single decision framework, enables span-level risk to be calculated rather than estimated.

Risk concentrates on a handful of spans - Across every circuit studied, the vast majority of outage risk came from a small number of spans. Crews don't need to walk every line, knowing exactly which spans to target means field time and inspection dollars go where they produce the greatest reduction in customer outage risk.

The investment return peaks early - The biggest gains come at modest investment, typically \$100K–\$200K per circuit. The model identifies not just which spans are at risk, but which mitigation action delivers the best return at that location. Getting this right before crews go into the field avoids unnecessary inspections and misallocated capital.

Study Limitations & Questions to Explore

Industry Perspective

Daniel Stevens

National Grid

Known Limitations

- Only 3 mitigation options modeled. (i.e. covered conductors, automation (FLISR), and DER investments outside scope).
- Models did not account for individual branches or multi-benefit strategies (e.g. can the mitigation protect against wind *and* ice hazards).
- Cost and impact data was derived from estimates and did not include utility-specific accounting.
- Model transferability varies by local vegetation, species, terrain, and maintenance practices.
- Climate/vegetation projections carry inherent uncertainty.

Recommended Next Steps

- Execute utility-specific proof-of-concept deployments to validate transferability.
- Integrate WISPR outputs into planning/work-management systems for operational use.
- Expand to additional mitigation strategies: tree wire, automated fault detection, DER hardening.
- Incorporate wildfire, ice, and snow risk to better justify undergrounding investment thresholds.

What this means for the industry

Precision beats proximity — a small subset of spans drives the majority of outage risk • LiDAR + outage records + climate + topology = one unified decision framework • Industry, academia, and technology each contribute what the others lack

- 01 Who owns the risk?** As risk probabilities become calculable, how do we balance customer expectations, regulatory priorities, utility-informed mitigation strategies, and the costs of insurance? There is a need to continue working across sectors, with government, regulators, academia and the public.
- 02 How do we move in the direction of real-time data and AI informed analysis?** Vegetation grows, climate projections improve, asset performance and maintenance details constantly change — while rate-case cycles are fixed, we need to make longer-term investment decisions based on a snapshot in time. Leveraging AI has the potential to inform these decisions and the real-time application of mitigation strategies.
- 03 Can the framework justify undergrounding?** Today, the cost of undergrounding is rarely justified within the time horizons we're considering, but as wildfire, ice, and climate risk are added to the model, at what combined risk threshold does undergrounding become the efficient choice over the next 30, 40, 50 years?
- 04 What does a climate-resilient grid standard look like?** Mid-century projections show materially higher wind-gust frequency. Should we use risk-plus-climate frameworks like WISPR for long-term resiliency planning?
- 05 What else?** What should we be thinking about? Audience input, Q&A.

Thank You

WISPR: Wind Impact Study for Power Resilience

Presenting Team

Greg Itzstein | Pointerra — Program Lead

Daniel Stevens | National Grid — Utility Partner

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