

# MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 23-505 (project 617) | September 2023

Modeling Disrupted  
Transportation  
Infrastructure System due  
to Fallen Trees under Wind  
Hazards



## the ISSUE

The interaction between transportation networks and buildings damaged by earthquakes has been extensively studied. In contrast, despite catastrophic consequences to human life and infrastructures resulting from tree failure in windstorms, research on the risk of disruption to critical infrastructure caused by tree damage is very limited.

## the RESEARCH

In this study, researchers first developed equations to account for the relationship between various tree characteristics, such as species, height, and trunk diameter, for three urban tree species to facilitate the development of the mechanistic model and fragility curves. Second, a mechanistic model based on finite element modeling was built with the direct stiffness method by considering wind profile, wind loads, and self-weight of trees. Third, fragility curves of three tree species were generated for both stem-breaking and uprooting limit states through Monte Carlo simulation. Finally, the performance of critical infrastructures disrupted by fallen trees in the city of Fort Collins, Colorado, such as transportation and overhead powerline infrastructures, was evaluated with the proposed probabilistic method.

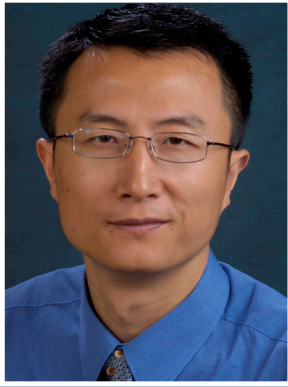


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University of Utah

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### Project Title

Modeling disrupted  
Transportation Infrastructure  
System due to Multiple  
Hazards

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### the FINDINGS

The proposed framework and matrix-based system reliability method are demonstrated in detail while studying the overhead powerline and transportation network of Fort Collins. In the demonstrative example, the probabilities of powerline disruption, road closure, and origin-destination disconnection and travel time reliability under different wind conditions are predicted. Finally, mitigation efforts such as crown thinning of trees are discussed to reduce possible risks of disrupting the infrastructures.

### the IMPACT

The proposed tree fragility and performance assessment framework can help people understand the risks of tree failure and the impacts to some critical infrastructures and the community resilience in a specific wind event. The research findings can potentially be applied in future risk assessment and mitigation of urban trees before windstorms. Accordingly, stakeholders can make risk-informed decisions in terms of effective prevention and preparation measures to protect these infrastructures and further improve the resilience of the whole community subjected to wind events.

For more information on this project, download the Main report at <https://www.ugpti.org/resources/reports/details.php?id=1141>

For more information or additional copies, visit the Web site at [www.mountain-plains.org](http://www.mountain-plains.org), call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.



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