UTC Project Information	
Project Title	Agent-based modeling framework for wildfire evacuation in damaged transportation settings
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Brief Description of Research Project	Wildfires pose an increasing threat to residents in the Pacific Northwest (PNW) region as more people are moving to the wildland-urban interface. In addition, the increasing frequency and magnitude of wildfires induced by climate change will greatly intensify wildfire threats to human and economic losses in the PNW region. While many state- and local-level initiatives are underway to mitigate wildfire risks, it is not possible to completely remove such risks due to substantial inherent uncertainties. In this case, evacuation is the most important and effective method to reduce human losses during a wildfire event. The main goal of this study is to support effective evacuation planning by developing an agent-based modeling framework for wildfire evacuation in damaged transportation settings. The framework predicts traffic conditions during an evacuation and identifies the critical parts of the transportation network for pre-fire risk mitigation actions aimed at improving mobility during a wildfire evacuation.

Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	Effective community-based transportation evacuation planning is an important issue for state and local policymakers at great risk of wildfires in the United States. During the project period, the research outcomes were shared in a poster session (see the poster below) at the 2022 Region 10 Transportation Conference. We will continue our efforts in distributing these outcomes and communicating with state and local agencies to help them use the results in developing their evacuation planning.

WASHINGTON STATE UNIVERSITY

Agent-Based Modeling Framework for Wildfire Evacuation in Damaged Transportation Settings

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Background

- Wildfires pose an increasing threat to residents in the PNW region
- Evacuation is one of the most important and effective methods to reduce human losses during a wildfire
- Mass evacuation can lead to severe traffic congestion and reduce mobility, thus endangering human lives
- Bridge damage may further exacerbate the problem

Research Goal

- Support effective evacuation planning by developing an agent-based modeling framework for wildfire evacuation in damaged transportation settings

Framework

- Integrate wildfire simulation, vulnerability assessment, evacuee response model, and traffic simulation

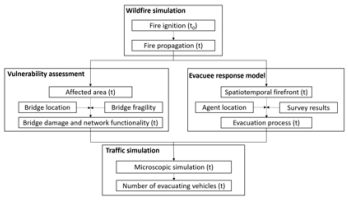

Fig 1. Flowchart of the proposed framework

Data Collection: Online Survey

- Online survey of residents in wildfire-prone areas in CA, OR, and CO
- Participants recruited through Amazon MTurk
- 853 valid responses
- Questionnaires about demographic information, property location, car ownership, mobility issue, risk perception, previous experience with wildfire, and evacuation responses and behaviors

Data Analyses and Survey Results

- Logistic regression analyses to identify key independent variables that influence (a) evacuation timing and (b) the use of real-time navigation during a wildfire evacuation
- Binary evacuation decision
  : early evacuation vs. delayed evacuation

- Binary logistic regression results (1 = Evacuate early)

Variable	Estimated coefficient	p-value
Intercept	0.6906	0.0009
Education: high school diploma or equivalent	-0.5674	0.0066
Household income: 100k-200k	-0.3681	0.0433
Household income: over 200k	-0.5024	0.0395
Household size: 1 person	-0.7043	0.0013
Cars per household: 3 or more	-0.8329	0.0008
Animals: both pets and livestock	-0.8279	0.0175
Navigation: use under normal conditions	0.3840	0.0348
Homeowners insurance: fully insured	0.4884	0.0034
Past evacuation: more than once	0.6992	0.0010

Case Study

- The 2017 Rye Fire in the City of Santa Clarita, CA
- Five massive bridge damages out of 11 bridges
- Synthetic population: 83,558 households; 246,830 residents

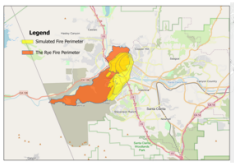

Fig.2 Simulated fire vs. the Rye Fire

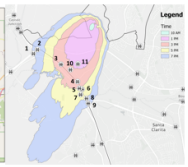

Fig.3 Bridge locations and damages

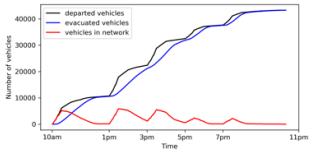

Fig.4 The number of vehicles that have departed or evacuated, and the number of vehicles in the network

Fig.5 Traffic map at 10:36 am

Conclusions

- Improve the accuracy of wildfire evacuation in damaged transportation settings by incorporating advanced wildfire hazard modeling and vulnerability assessment
- Better understand individual evacuee behaviors

Impacts/Benefits of Implementation (actual, or anticipated)	The developed evacuation simulation model can assist a well-developed evacuation plan and ultimately could save human lives. More specifically, the outcomes of this project include (a) the comprehensive evacuee response model based on the web-based stated preference survey and (b) the agent-based modeling (ABM) framework for wildfire evacuation in damaged transportation settings. The evacuee response model can be used to predict individual evacuees' behavior as a firefront approaches, which may help state or local agencies prepare an effective evacuation planning guide or identify the appropriate timings of various evacuation orders. The proposed ABM framework introduced damaged traffic settings to the evacuation process and showcased how the reduced network capacity impacted evacuation efficiency, especially when combined with the elevated travel demand. The simulation results can be used to identify bottlenecks and critical network segments that may experience heavy congestion during an evacuation. Thus, as pre-fire mitigation actions, the identified network components and segments can be retrofitted or expanded, while alternative routes are constructed, aimed at facilitating evacuation during a wildfire event.
Web Links • Reports • Project Website	