Wildfire Risk Indices & the Built Environment:

Part 1 - An Inventory of Current Models

Winter 2025

HEADWATERS ECONOMICS

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About Headwaters Economics

Headwaters Economics is an independent, nonprofit research group whose mission is to improve community development and land management decisions. https://headwaterseconomics.org/

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1. Purpose and Introduction

Accurate models of wildfire risk are needed to inform disaster preparedness, land use planning, and land management decisions. As wildfire risks increase and as populations expand into wildfire-prone areas, the potential of fires entering and spreading through neighborhoods is also increasing. Recently, fast-moving urban conflagrations have destroyed thousands of structures and cost billions of dollars in response and recovery, including recent disasters in Los Angeles, California; Lahaina, Hawaii; and Boulder County, Colorado..[1] However, emerging science that captures the physical and probabilistic processes of how fires ignite homes and spread through the built environment has not yet been operationalized in national, publicly available models of wildfire risk.

Most existing wildfire risk models focus on wildland fire spread and the intersection with the wildland-urban interface (WUI) without directly accounting for propagation of fire between buildings. Fire spread in the built environment is driven by localized characteristics that are difficult to model, such as the building materials on individual structures, housing density from low (e.g., WUI) to high (e.g., urban), and patterns of development (e.g., regular spacing versus clustering). Data about these components in the built environment is limited.

The purpose of this report is to shed light on the state of the wildfire risk modeling field and the opportunities for integrating principles of structure-to-structure ignition. This research includes an inventory and evaluation of gaps and opportunities for addressing risk to the built environment within existing fire risk indices, with a focus on products that could be made nationally consistent and publicly available for government use. This study, along with a forthcoming analysis of interviews of subject-matter experts, is intended to help bring clarity and coordination to efforts to fund, develop, scale, and operationalize the next generation of wildfire risk models.

Headwaters Economics was engaged by the U.S. Fire Administration and partnered with Pyrologix, a Vibrant Planet Company and wildfire threat assessment research firm, to conduct the research. The research includes two phases: (1) a literature review to evaluate the degree to which the built environment is addressed by various models, and (2) interviews with subject matter experts to catalogue the gaps in methodologies and options for resolving those gaps. This report summarizes the outcomes of Phase 1.

DEFINITIONS

Terms for the purposes of this study:

Built environment: Human-made areas where people live and work, including structures (homes, offices, schools, and other buildings), infrastructure (roads, bridges, etc.), and utilities (water supply, sewage systems, and electrical grids).

Exposure: Placement and orientation of structures that could be adversely affected by wildfire via the three primary mechanisms of ignition: ember attack, radiant heat, and direct flame contact.

Hazard: Potential occurrence of a wildfire entering the built environment and its associated fire behavior characteristics that could cause damage or loss to property.

Risk index: The output of a risk modeling workflow. It is typically represented on a relative scale of low to high.

Risk: The potential for wildfire-induced damage to or loss of structures and property. For the purposes of this study, risk is composed of the intersection of four main risk components: hazard, exposure, vulnerability, and structure-to-structure (S2S) ignition processes.

Structure-to-Structure (S2S): Process whereby structures become a source of embers, radiant heat, and flames that can spread fire to nearby structures.

Vulnerability: Degree to which structures are predisposed to be adversely affected by wildfire, which includes structure characteristics such as condition of roofs, eaves, and decks as well as characteristics of the home ignition zone and surrounding neighborhood.

Wildland-Urban Interface (WUI): The area where flammable vegetation and the built environment meet or intermingle.

2. Conceptual Framework and Approach

The analysis evaluated existing wildfire risk models with a focus on how they account for the built environment (i.e., homes, buildings, infrastructure, and neighborhoods) in risk indices and whether they can be operationalized at a national scale.

Risk in the Built Environment

In particular, this research focused on the ability of models to incorporate structure-to-structure (S2S) ignition because it drives urban conflagrations and capturing it in risk modeling is inherently complex. Further, S2S is logically interconnected to the three commonly identified risk components: hazard, exposure, and vulnerability.[2] For example, structures are a source of fuel and contribute to hazard; structure proximity and density influence heat transfer and ember load, contributing to exposure;[3] structure flammability affects loss and contributes to hazardous fuel load, contributing to vulnerability. To capture this complexity, we built on the concept of the "risk triangle" and developed a "risk pyramid" (Figure 1).

For this project, the pyramid is used as an organizing framework for understanding various risk modeling approaches. The pyramid is a useful organizing construct that allows us to:

- Classify risk indices
- Develop standard evaluation criteria
- Stratify families of models
- Highlight model integration
- Depict how the built environment is incorporated into risk models

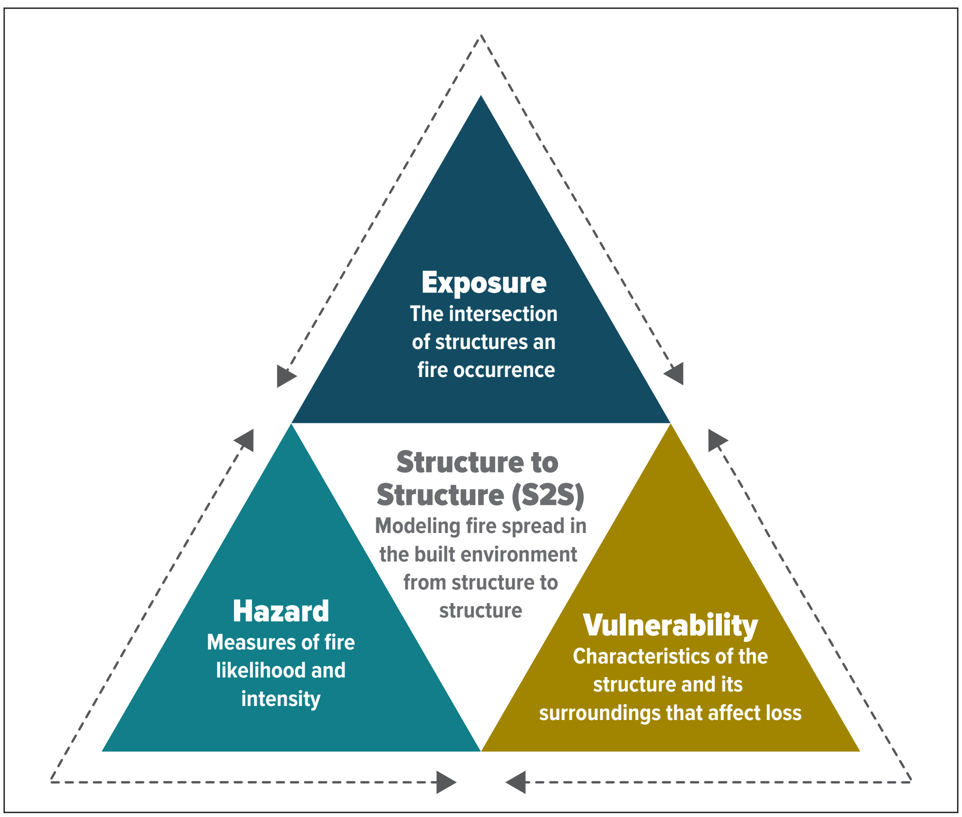


Figure 1: The Risk Pyramid used to depict the four main components of wildfire structure risk, with a specific focus on structure-to-structure risk.

Operational Scale

Risk models are designed for a variety of intended uses and will therefore be more or less relevant to different audiences and contexts. For the purposes of this analysis, our focus is on models that can be scaled to operate at a national level. However, the more land area a model covers, the more that model must rely on general assumptions over facts on the ground. This inherent tradeoff is the crux of this research: What methods and approaches maximize both detailed information and national readiness?

WUI VERSUS RISK

The Wildland-Urban Interface (WUI) is the area where homes and other structures meet and intermingle with flammable wildland vegetation. The WUI is generally a geographic area, not a measure of risk.[4] We did not include Wildland-Urban Interface (WUI) maps in our analysis because they do not generate risk indices.

3. Methodology

The methodological approach for this study followed a four-step process: literature review and model filtering; evaluation and scoring of risk components and operational readiness; identification of model families; categorization of risk outputs or indices. Each step is described further below.

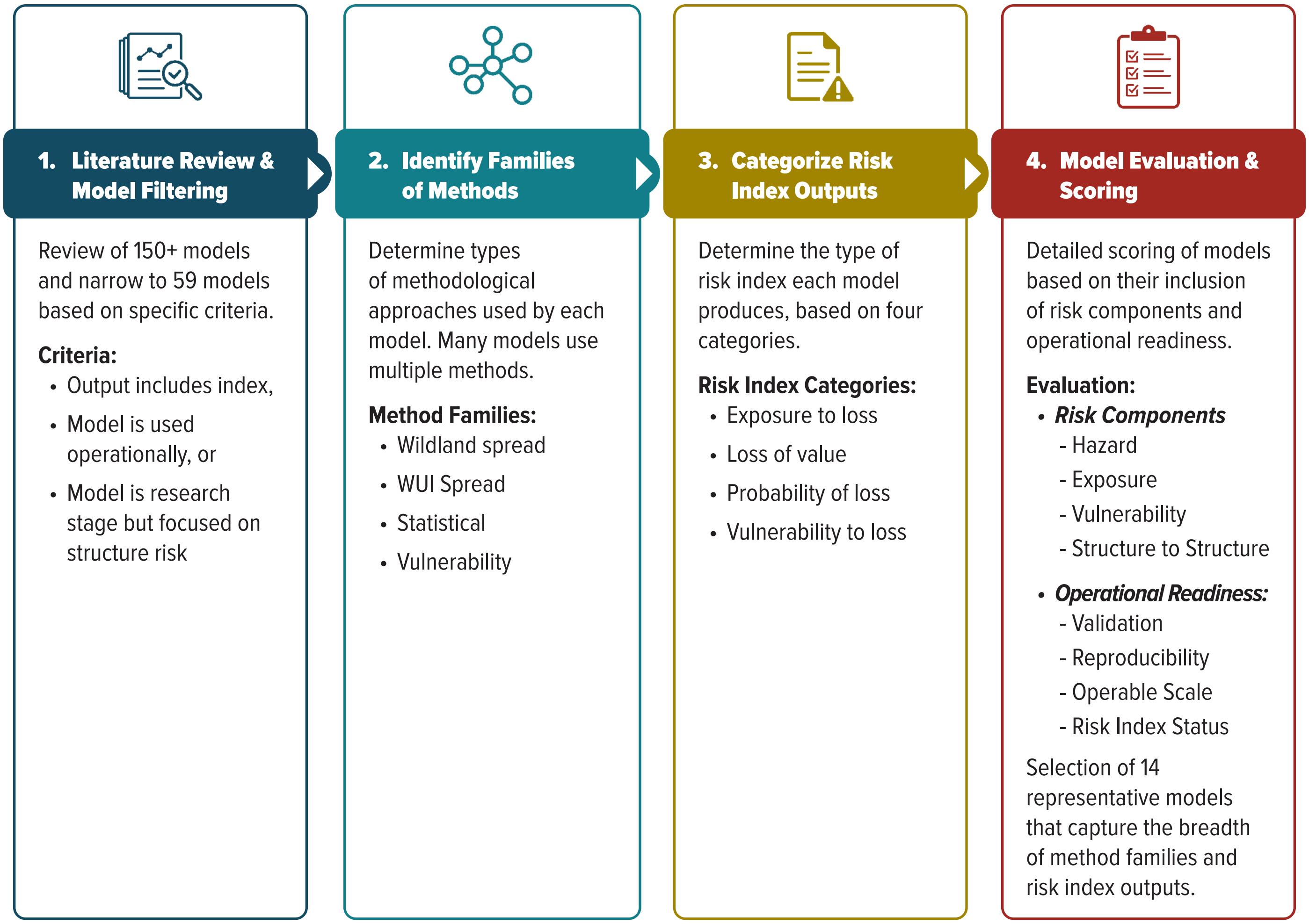


Figure 2. Four-step methodological approach used for this report.

1. Literature Review & Model Filtering

The study began with an extensive literature review, consulting over 150 models, reports, and studies from various sources. A decision tree (shown in Appendix A) was developed to filter these models based on specific criteria, including whether each model:

- has an output that includes an index,
- is used operationally, or
- if not used operationally, is focused on structure risk.

The final set included 59 models that met the selection criteria (shown in Appendix B). Of these modeling approaches, many used the same underlying methodology or had common approaches.

Some types of models were excluded from consideration. Due to their inherently concealed methodology, models that are largely or completely proprietary were omitted this analysis. Physics-based, computationally expensive models tend to be used for experimental purposes and not yet deployed for community analysis and were also omitted. Studies implemented outside the United States were also excluded. Although some international analyses may have applicable methods, in most cases there was not sufficient data or methodological overlap with those from the U.S. Additionally, the United States has some unique fire management challenges, for instance legacies of fire exclusion and housing development patterns.

PROPERTY INSURANCE & RISK MODELING

Property insurance companies are interested in risk analyses at all scales. They seek national risk analyses to help price their services regionally based on risk and to purchase reinsurance. They are also interested in granular information to help with underwriting specific properties based on estimated damages and losses. Most insurance companies use proprietary datasets and models through subscription services. These proprietary models inherently conceal their methodology and are thus beyond the scope of this analysis. Further, the methodology that insurance companies use to price and develop their products are not public. Therefore, the relationship between actual and modeled risk and insurance affordability and availability is known only to insurers.

2. Identifying Families of Methods

The set of 59 models was grouped into four main categories, or families of risk modeling methods: wildland fire spread, WUI fire spread, statistical, and vulnerability models. Each family has different scales of application and advantages and limitations (Table 1). Importantly, many models used more than one family of methods, resulting in complex relationships among the selected models and their methodological approaches.

Table 1: Families of Methods

Methodological Family	Description	Typical Scale	Example Uses
Wildland Fire Spread Models	Capture the influence of topography, weather, and flammable vegetation on fire spread potential. They characterize risk impact to the built environment through wildland fire exposure.	• National • Regional • Multiple communities	• Informing decisionmakers about landscape-level hazard exposure to communities • Prioritizing wildland fuels reduction and response planning • Community planning for future development
Wildland-Urban Interface (WUI) Fire Spread Models	Simulate wildfire spread through communities. They operate in the built environment and are sometimes able to be initiated with outputs of wildland fire spread models.	• Single community • Single structure	• Community planning for future development • Planning for emergency response • Managing flammable vegetation within the community
Statistical Models	Data-driven model based on historical structure loss data. Does not model physical fire spread, but can be paired with fire models.	• Any scale	• Understanding structure survivability and parcel- and neighborhood-level characteristics • Informing neighborhood design and building arrangement • Modeling the effects of future climate and land use change on WUI risk
Vulnerability Models	Characterize the vulnerability of a structure to ignite, largely independent from assessment of wildfire likelihood or intensity, but can be paired with fire models. Focus on characteristics of the built environment such as windows, eaves, decks, and roofs.	• Single community • Single structure	• Informing decision-makers and residents about structure, parcel, and neighborhood features that influence ignitability • Informing and prioritizing defensive actions on individual structures • Prioritizing home ignition zone mitigation, defensible space, and vegetation management • Planning for emergency response

3. Identifying Risk Index Categories

To further evaluate each of the 59 models, we categorized the model output (i.e., its "risk index") into four main groups. In the ideal model, risk indices are forward-looking, focused on possibility and probability, and consider all elements of the risk pyramid. The four Risk Index categories are described in Table 2.

Table 2: Risk Index Categories

Risk Index Category	Description	Risk Components	Families of Methods	Example Indices
Exposure to Loss	Estimation of exposure to loss based on spatial overlays of WUI/structure location data with wildfire hazard information	• Hazard • Exposure	• Wildland spread • WUI spread	• Mean annual number of homes exposed • Probability of fire occurrence in developed parcel • Wildfire exposure score • WUI burned area
Loss of Value	Estimation of potential loss or damage, often pairing fire hazard models with loss or damage functions incorporating information on fire intensity and other factors	• Hazard • Exposure • Vulnerability • S2S	• Wildland spread • WUI spread • Statistical • Vulnerability	• Average annual loss • Building damage • Net value change (NVC)
Probability of Loss	Estimation of probability of structure loss, often pairing fire hazard models with statistical models based on historical loss data	• Hazard • Exposure • Vulnerability • S2S	• Wildland spread • WUI spread • Statistical • Vulnerability	• Expected number of ignited structures • Structure ignition probability • Probability of house loss
Vulnerability to Loss	Estimation of vulnerability to loss or damage, often based on characteristics of the home and its surroundings	• Vulnerability	• Statistical • Vulnerability	• Parcel risk score • Structure vulnerability index • Wildfire resistance index

4. Evaluation & Scoring

Next, the 59 models were evaluated using a standardized scoring system. The system is based on two primary themes:

- **Risk Components.** The degree to which the built environment is addressed in each of four risk components: hazard, exposure, vulnerability, and structure-to-structure (S2S) ignition.
- **Operational Readiness.** The degree to which each model is suitable for the overarching purpose of supporting public, broadscale structural risk assessment with transparent, credible methods and data.

Within each theme, models were scored on four criteria on a scale from zero to three, with three indicating the highest level of incorporation or readiness (Table 3). This quantitative scoring system enabled side-by-side comparisons of the models and facilitated the identification of commonalities and divergences.

Table 3. Scoring Criteria for Model Evaluation

Theme	Criteria	Scoring			
		0	1	2	3
Risk Components	**Hazard** *Is built environment incorporated, including structures as fuel?*	No consideration	Wildland as only source of hazard	Proxies for built environment as a source of hazard (e.g., custom fuel models)	Built environment as a source of hazard
	Exposure *Does exposure information include all mechanisms (radiation, convection, and ember cast)?*	No consideration (e.g., a home vulnerability analysis only)	Includes one type of exposure	Includes two types of exposure, including proxies for firebrands or spatial smoothing	Includes three types of exposure (convection/direct flame, radiation and firebrands)
	Vulnerability *Is built environment included, such as structural and home ignition zone attributes?*	No consideration (e.g., an exposure analysis only)	Includes information on wildland exposure only	Includes information on structure density or arrangement	Includes information on structure and home ignition zone attributes
	Structure-to-Structure *Are structure-to-structure ignition processes incorporated?*	No consideration	Implicit (e.g., through custom fuel model or use of structure density)	Explicit, but does not include structure attributes	Explicit, and includes structure attributes
Operational Readiness	**Validation** *Have model results have been calibrated and validated?*	No calibration or validation demonstrated	Calibration based on historical fire occurrence and expert judgment	Calibration based on historical structure loss data or expert judgment	Validation of predictions based on comparison to historical outcomes on structure loss
	Reproducible *Are methods, data, and software publicly available?*	Not feasible to reproduce	One of data/ methods/ models are available	Two of data/ methods/ models are available	Three of data/ methods/ models are available
	Operable Scale *Does the model support broad-scale assessment?*	Experimental or conceptual	Case study or Community	Regional	National
	Predictive Status *Is the index capable of supporting predictive analysis?*	Experimental or conceptual	Retrospective - proof of concept	Predictive capable - not deployed	Predictive - deployed

4. Key Findings

To illustrate key findings, 14 representative models were selected to demonstrate the breadth of method families and risk index categories. The complete evaluation of the 14 representative models is shown in Table 4. Here, we summarize key findings from the evaluation. Appendix C details further commonalities and divergences.

Current models face a tradeoff between operational readiness and detailed assessment of risks in the built environment.

At present, it is challenging to achieve both scalability and detail on built environment—models that are operationally scalable tend to lack the granularity needed for precise predictions of fire behavior in urban settings, while models that offer detailed insights into the built environment often lack the scalability or readiness for widespread use.

A scatterplot comparing Risk Component Scores and Operational Readiness Scores helps visualize contrasts across the representative studies (Figure 3). Tradeoffs in scope, scale, and granularity of the models are apparent.

The scatterplot helps highlight some important observations:

- **There are many operational models that do not comprehensively account for risk** in the built environment, especially the Exposure to Loss and Loss of Value models. Those with lower scores in the lower left quadrant (Cluster 1 in Figure 3) tended to focus on exposure or vulnerability without consideration of the entire set of risk components, including S2S.

  Across the Exposure of Loss and Loss of Value models, the use of Rothermel-based models is common, including the Missoula Fire Lab's FSim fire modeling system.[5] With the exception of Zuzak et al. (2023),[6] all Loss of Value studies were generally patterned after Scott et al. (2013),[7] although different approaches to characterize damage/loss were used.

- **Some models account for more built environment risk, but lack operational readiness**. The Probability of Loss models built with WUI fire spread models (P.1, P.2, and P.3 in Table 4; Cluster 2 on Figure 3) scored highest on Risk Components and score high on S2S but are not yet operable for predictive use at scale. The Probability of Loss studies were generally more detailed regarding the built environment. With the exception of Syphard et al. (2019)[8] (P.4)—whose focus included climate change and land use projections—all Probability of Loss models directly modeled structure-to-structure ignitions and summarized loss probability at the level of individual buildings. The WUI spread models in this category generally used a coarser approach to characterize fuels and did not generate predictive indices, but rather were used retrospectively on case study examples.

  Vulnerability to Loss studies were the most detailed at the structure level, including multiple attributes of structures and parcels, but these approaches did not include modeled hazard or exposure characteristics. Notably, Meldrum et al. (2022)[9] (V.2) was the only study we found that attempted to validate prior risk assessment predictions against observed structure loss in the East Troublesome Fire.

- **Several models show promise for advancing the field, representing the efficient frontier**. These include four representative models: L.4, L.5, P.1, and P.2. Advancement of the efficient frontier would consist of either incorporating additional information on the built environment into existing operational models or increasing the validation and scalability of WUI spread models.

Table 4: Results of model evaluation

Category	Model	Risk Index Output	Current Status	Model Families				Risk Component Score					Operational Readiness Score					Total Score
				Wildland Spread	WUI Spread	Statistical	Vulnerability	Hazard	Exposure	Vulnerability	Structure-to-Structure	**Subtotal**	Validation	Reproducibility	Operable Scale	Predictive Status	**Subtotal**	
Exposure to Loss	**E.1:** Ager et al. (2021)	Mean annual and extreme year building exposure	Operational	✔				1	1	0	0	**2**	1	2	2	3	**8**	**10**
	E.2: Efstathiou et al. (2023)	Probability of fire occurrence in developed parcel	Research		✔			2	2	0	1	**5**	1	1	1	1	**4**	**9**
	E.3: Kearns et al. (2022)	Wildfire exposure score	Operational	✔				2	2	0	1	**5**	1	2	3	3	**9**	**14**
Loss of Value	**L.1:** Dunn et al. (2023)	People and Property Net Value Change	Operational	✔			✔	2	1	2	1	**6**	1	2	2	3	**8**	**14**
	L.2: Jefferson Co. Open Space (2022)	WUI Net Value Change	Operational	✔		✔	✔	1	1	2	0	**4**	2	2	2	3	**9**	**13**
	L.3: Technosylva (2023)	Building Damage Potential	Operational	✔		✔	✔	2	1	2	1	**6**	2	1	2	3	**8**	**14**
	L.4: Zuzak et al. (2023)	Expected annual loss	Operational	✔		✔	✔	1	1	2	0	**4**	2	2	3	3	**10**	**14**
	L.5: Scott et al. (2024)	Housing Unit Risk	Operational	✔			✔	1	2	2	1	**6**	1	2	3	3	**9**	**15**
Probability of Loss	**P.1:** Chaluhwat et al. (2022)	Building survival likelihood	Research		✔		✔	3	3	3	3	**12**	2	1	1	1	**5**	**17**
	P.2: Purnomo et al. (2024)	Structure loss probability	Research	✔	✔		✔	3	3	2	2	**10**	2	2	1	1	**6**	**16**
	P.3: Masoudvaziri et al. (2023)	Expected number of ignited structures	Research		✔		✔	3	3	2	2	**10**	2	1	1	1	**5**	**15**
	P.4: Syphard et al. (2019)	Probability of structure destruction	Research			✔		2	1	2	1	**6**	2	1	2	3	**8**	**14**
Vulnerability to Loss	**V.1:** Dossi et al. (2022)	Wildfire Resistance Index	Research			✔	✔	0	0	3	0	**3**	2	1	2	2	**7**	**10**
	V.2: Meldrum et al. (2022)	Parcel risk score	Research				✔	0	0	3	0	**3**	3	2	1	3	**9**	**12**

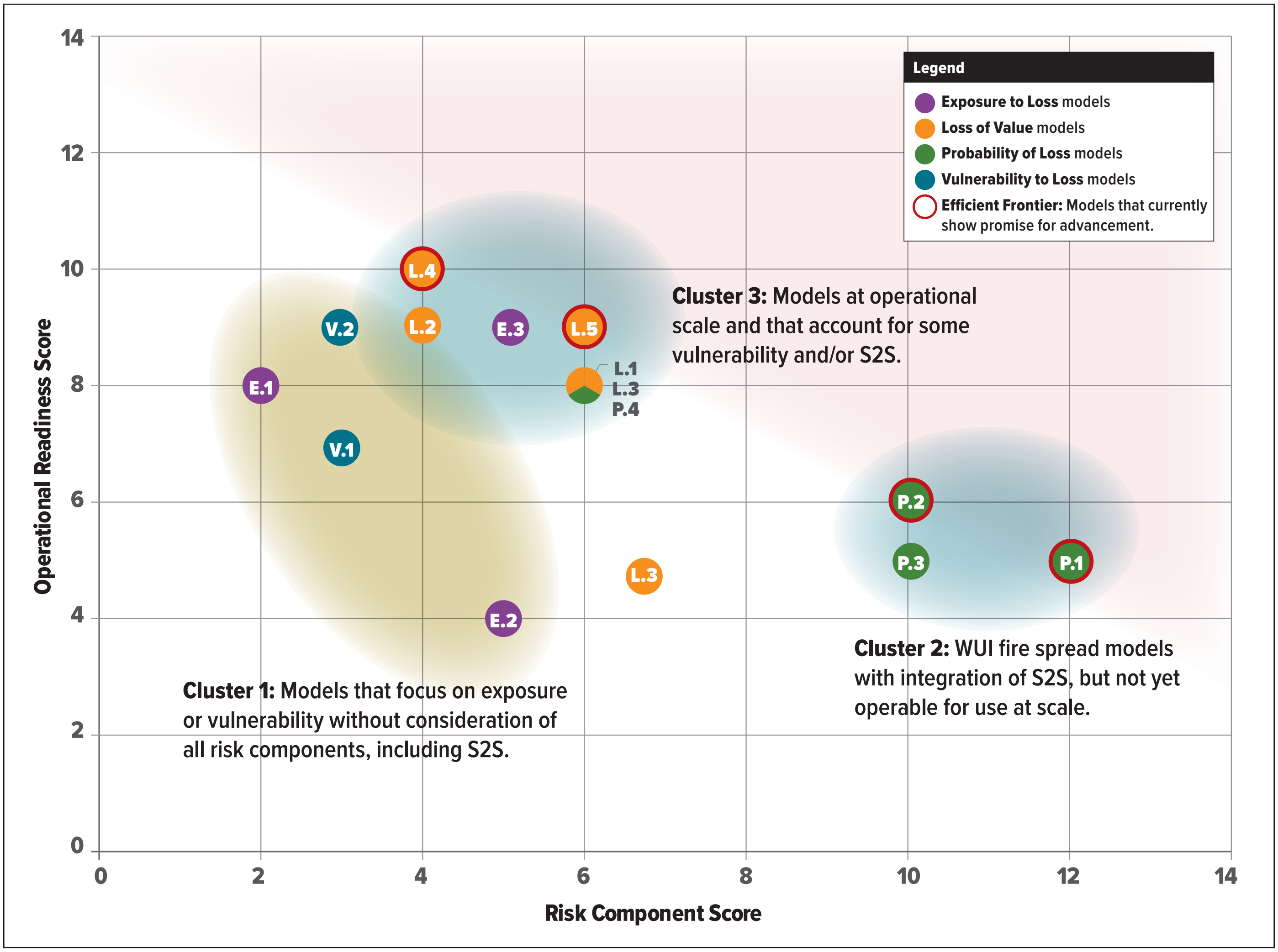


Figure 3. Scatterplot comparing Risk Component Score and Operational Readiness Score for the 14 representative models. Note that L1, L3, and P4 have the same score but are shown separately for visualization. The color of each dot corresponds to the model's Risk Index Category.

Investments could bridge the gap between operational readiness and built environment modeling.

Preliminary findings from Phase 1 research show a number of key, interrelated areas for improving sophistication and scalability of structural risk modeling. Advances in these areas can help operationalize models at a national scale that integrate more detailed information about structure-to-structure risk. There are several areas ripe for investment that can be simultaneously explored, including:

1. **Improve inputs: support development and integration of novel data about structure and neighborhood characteristics.** More experimental data, post-fire damage observation data, and pre-fire housing characteristic data will all help improve calibration and application of structure risk models. As data acquisition and processing paired with machine learning improves, it will likely inform integration of more detailed features like customized fuel models and structure vulnerability functions into operational, scalable risk indices.
2. **Improve methods: support advancements in predictive modeling**. Predictive modeling that accounts for the physical characteristics of fire in the built environment (such as fluid dynamics, heat transfer, and ember generation) appears promising for improving risk indices, but requires significant computational power and is therefore limited to small spatial domains. Physics-based modeling shows promise for informing the assumptions and processes of more computationally efficient WUI fire spread models. As WUI fire spread modeling capabilities mature in the research environment, we will see improved physics-based predictive modeling, data and modeling integration, and computationally efficient processing, among other improvements.
3. **Improve outputs: support enhanced validation and verification of predictive modeling.** Very few of the studies compared prior risk modeling results to observed outcomes, and several were tested only retrospectively against a small number of events. As data and methods improve, there will be a commensurate need to validate performance of these models against a broader range of variable conditions and geographies. The scientific and modeling communities could help collectively identify a set of best practices and common datasets against which to benchmark model performance.
4. **Improve accessibility: promote open science and transparency, and invest in front-end application development that ensures improved structure risk models are accessible and useful for decision-making.** It can be very expensive to take models from research demonstration to operational decision support. Many of the modelling approaches in this report require further validation, which is currently limited by data availability and methodological transparency. Making data accessible for decision-support requires a different set of key capabilities, such as user experience design and software engineering. To make models fully accessible to decision-makers, investments are needed in open source data and methods, front-end applications, user interfaces, validation, and science translation.

The second phase of this research project will delve further into these and other gaps and opportunities.

5. Conclusion

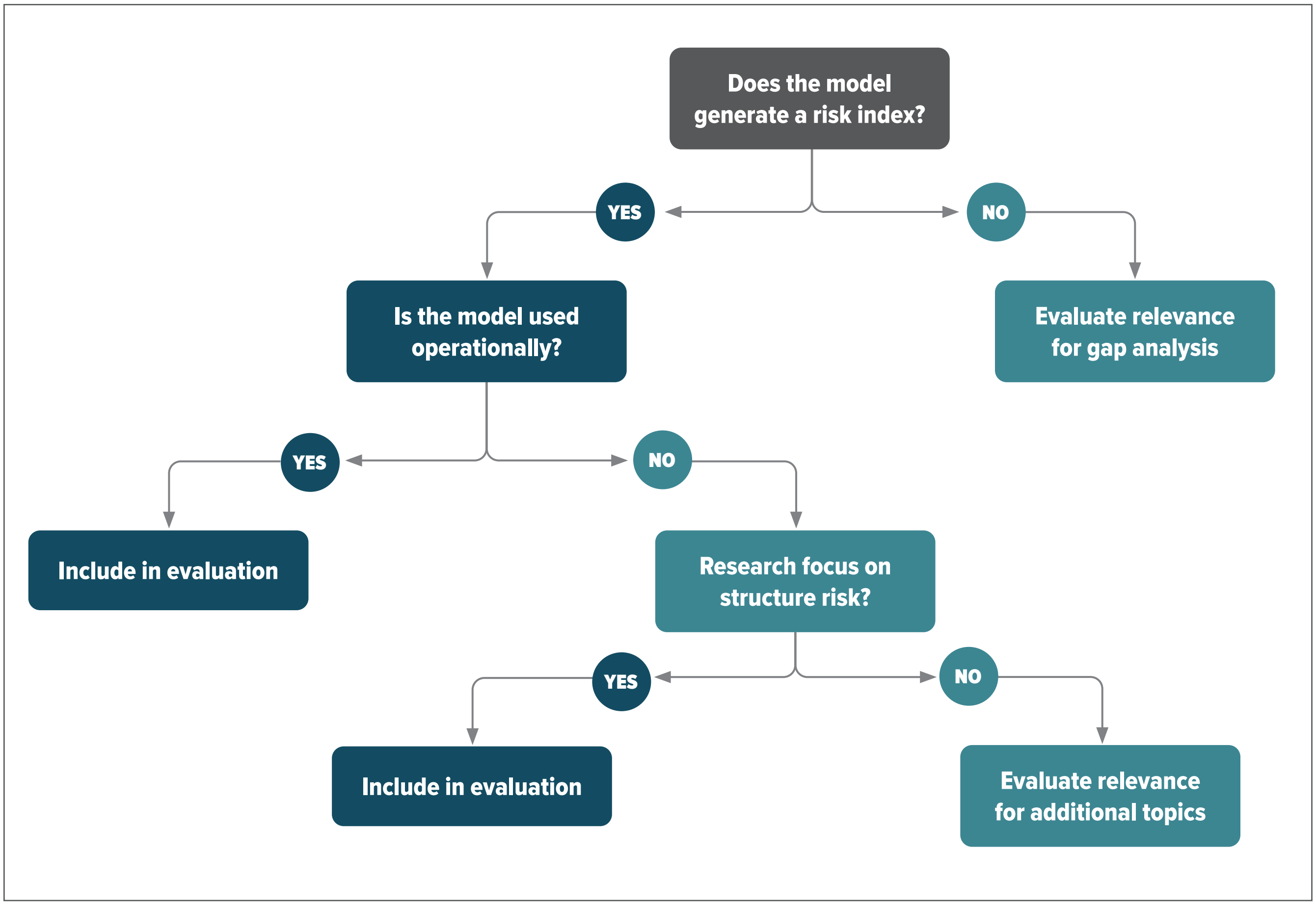
Predictions are essential for disaster planning by communities, land management agencies, utilities, and insurance companies. Operational models used for wildfire risk predictions typically focus on hazard, exposure, and some vulnerability, providing a broad overview of wildfire risk across large landscapes. These models inform fuel treatments, evacuation routes, and building code enforcement. Other models assess the vulnerability of individual homes, helping homeowners reduce risks, assisting insurers with underwriting, and aiding firefighters in evaluating structure defensibility. While structure-to-structure (S2S) models are not yet operational for these tasks, they provide detailed insights into community-level exposure and vulnerability, which can improve fuels treatments, evacuation planning, firefighter deployment, and building code requirements.

Current S2S fire spread models are still in early stages of development, focusing on improving input/output accuracy, system integration, and scalability. High degrees of uncertainty around structural ignition processes, particularly the physical properties of building materials, ember generation and transport, make parameterization of these models difficult. High computational demands mean these models often simplify fire spread by assigning flammability functions to coarse characterizations of structures and vegetation. This reduces computational expense, making them theoretically more accessible, but they have not yet been operationally deployed for predictive use.

Key areas for improving structural risk modeling include advancements in fire science, data, and technology. Gaps persist in understanding wildfire spread physics in the built environment, particularly firebrand generation. Limited experimental data on materials and conditions hinder accurate damage prediction and adaptability across diverse housing environments. Improved data collection paired with machine learning could lead to more sophisticated and accurate models. Additionally, scaling research models to operational use will require significant investment in software engineering and user experience design.

Appendix A: Decision tree

The following decision tree was used to evaluate model suitability for inclusion in the analysis. The decision tree was used to identify risk modeling products and risk indices that could be made publicly available, at scale, for government use.



Appendix B: Models that met selection criteria

More than 150 models, reports, and studies from various sources were evaluated for inclusion in this analysis. A decision tree (shown in Appendix A) was developed to filter these models based on specific criteria. The 59 models that met the selection criteria are listed here. The 14 representative models selected for inclusion in Table 4 and Figure 3 are noted with an asterisk (*).

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Appendix C: Commonalities and divergences

The areas of commonalities and divergences are data, operational environment, operational scale, audience, and application. The more land area a model covers, the more that model must rely on general assumptions over facts on the ground. This is the overarching theme of commonalities and divergences among models. One model's strength is another model's weakness. A stakeholder will prefer a given model over another depending on the model's application. We therefore emphasize that there is no "best" model. The most effective model for assessing and reducing wildfire risk depends on the scale at which risk is assessed and the question that a stakeholder seeks to answer.

Data

Commonalities: Built environment datasets are limited, and therefore several are commonly used, including USA Structures,[10] Microsoft Building Footprints,[11] and LandScan.[12] Characterization of risk components is also commonly described.

Divergences: Granularity of data required for analysis is inversely related to the ability of the data to generalize over large areas. Some models use proprietary datasets, for example the Zillow Bridge API,[13] which includes property record attributes.

Operational Environment

Commonalities: The three operational environments are wildlands, wildland urban interface, and urban. All models seek to characterize risk to the built environment.

Divergences: The environment in which models operate varies, and few models operate across all environments. Wildland fire spread models operate in the wildlands and characterize risk impact to the built environment through wildland fire exposure. WUI fire spread models operate in the built environment and are sometimes able to be initiated with outputs of wildland fire spread models. Some WUI fire spread models can simulate pathways from nearby wildlands into the built environment. Vulnerability models operate exclusively in the built environment.

Operational Scale

Commonalities: All models seek to characterize risk to the built environment. The operational scales include single-structure, single-community, multiple-community, and regional-national.

Divergences: The granularity of risk characterization varies among model families. Vulnerability models and WUI fire spread models operate at the single-structure and single-community scales. Wildland fire spread models operate at the multiple-community and regional-national scales. Some proprietary models operate at all scales.

Audience

Commonalities: The outputs of all models can be used by any audience to better understand and plan for wildfire risk.

Divergences: Different audiences are interested in analyses at different scales. Home insurance companies are interested in analyses at all scales. They seek national risk analyses to help price their services regionally based on risk. They are also interested in the most granular information of any audience in order to help with underwriting specific properties based on the building's materials, HIZ and environmental context (e.g. topography, building arrangement, proximity to wildlands). Community managers and development planners are interested in the single-community scale. Land managers and state agencies are typically interested in the single-community and regional-national scales. Vulnerability is the only model family that can be easily interpreted and acted upon by homeowners. Proprietary models seek to provide widespread (national or regional) assessments of very granular data through proprietary datasets accessed by insurance, utilities, communities, and real estate agencies through database subscriptions.

Application

Commonalities: All models can help stakeholders understand wildfire risk to the built environment and its inhabitants.

Divergences: The aspects of wildfire risk have different levels of importance depending on the question that the user of a model seeks to address. Model families diverge in their ability to answer different questions. Vulnerability models are best suited to answer questions about single structures and the features of the structures and their environments that influence the structure's ignitability. Vulnerability models at the community level can also be useful for community planning in terms of developing a community risk index, planning future development, identifying socially vulnerable populations, planning for emergency response, and managing urban forestry. WUI spread models can answer most of the same questions as vulnerability models, but the path to the answer is through the simulation of wildfire spread through a community, and they do not include as much structure-level information as vulnerability models. Wildland fire spread models are best suited to answer questions about landscape-level hazard exposure to communities, including smoke exposure. They are the best models for simulating the effects of climate change, and can provide community risk indices and inform future development of the built environment. They are also the best models for prioritizing wildland fuels reduction. Proprietary models seek to answer as many questions for as many stakeholders as possible, although the validity of the answers is hidden so we are unable to fully assess them.

Endnotes

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