FIRE WALL

<u>F</u>oundations for <u>I</u>mproving <u>R</u>esilience in the <u>E</u>nergy Sector against <u>W</u>ildfires on <u>AL</u>askan <u>L</u>ands (FIREWALL)

Energy and Climate Technologies for the Arctic
May 3rd, 2024

UAA
UNIVERSITY of ALASKA ANCHORAGE

NSF

Wildfires and the Electricity Grid: Texas

- The Smokehouse Creek Fire escalated into one of the most devastating wildfires in Texas's history.
- Xcel Energy's shares fell 8% after the company disclosed a letter it received from a law firm that said the electric utility could be held liable for damages resulting from the largest wildfire on record in Texas.

Xcel Energy Utility Equipment Started Texas Wildfire, Homeowner Says in Lawsuit

By Reuters | March 1, 2024, at 7:18 p.m.

Save Comment

REUTERS

Smoke rises from a wildfire in Texas, U.S., February 27, 2024 in this screen grab obtained from a social m Bartlett/via REUTERS/File Photo

By Clark Mindock

(Reuters) -A Texas homeowner whose house was destroyed by a massive wildfire raging northeast of Amarillo sued electric utility Xcel Energy on Friday, alleging that a splintered power pole owned by the company fell and started the blaze.

Business

Xcel Energy Is Sued Over Worst Wildfire in Texas History

- Power equipment sparked massive blaze, according to suit
- Xcel market value has slumped; utilities face multiple claims

A burned car and home following the Smokehouse Creek Fire in Fritch, Texas, on March 1. *Photographer: Jordan Vonderhaar/Bloomberg*

Ref: https://www.usnews.com/news/us/articles/2024-03-01/xcel-energy-utility-equipment-started-texas-wildfire-homeowner-says-in-lawsuit
https://www.bloomberg.com/news/articles/2024-03-01/xcel-energy-is-sued-over-worst-texas-wildfire-in-state-history

FIRE WALL

Wildfires and the Electricity Grid: Hawaii

- During the summer of 2023, spectators were horrified as fires ravaged the island of Maui, resulting in the tragic loss of human life.

- In the words of Hawaii Electric's Chief Executive, "The company did not have a program that could shut off power preemptively to prevent wildfires. Power shutoffs would have made it impossible for people to use medical equipment, water pumps, and other essential devices."

- A utility spokesperson explained that it is difficult to enact "preemptive, short-notice power shutoffs" because they must be coordinated with first responders and that "notifications also need to be made to customers with special medical needs who use specialized equipment."

The Washington Post
Democracy Dies in Darkness

Hawaii utility faces scrutiny for not cutting power to reduce fire risks

Before the Maui wildfires, Hawaiian Electric did not have a plan — adopted widely in California and other states — to shut off power in certain lines in advance of dangerous winds

By Brianna Sacks

August 12, 2023 at 10:27 a.m. EDT

Fallen communications and power lines are seen Thursday after the wildfire tore through Kapunakea Street and Honoapiilani Highway in Lahaina, Hawaii. (Mengshin Lin for The Washington Post)

https://www.washingtonpost.com/climate-environment/2023/08/12/maui-fire-electric-utility/

FIRE WALL

Wildfires and the Electricity Grid: California

- Electric utilities in Hawaii and Texas are not the first companies to find themselves in the spotlight after major wildfires.

CNN US Crime + Justice Energy + Environment Extreme Weather Space + Science

HAPPENING NOW
Special coverage of the Super Tuesday primaries. Watch CNN

Utility giant PG&E agrees to $45 million settlement related to California's second-largest wildfire

By Taylor Romine and Aya Elamroussi, CNN
3 minute read · Published 1:39 AM EST, Fri January 26, 2024

The Dixie Fire destroyed hundreds of structures, including many Greenville in Plumas County. Noah Berger/AP

(CNN) — Pacific Gas and Electric will pay $45 million in penalties for its role in the Dixie Fire – the second-largest wildfire in California's history – that started after a tree fell and hit the company's equipment in 2021, state regulators said Thursday.

Ref: https://www.cnn.com/2024/01/26/us/pacific-gas-electric-settlement-dixie-fire-california/index.html

FIRE WALL

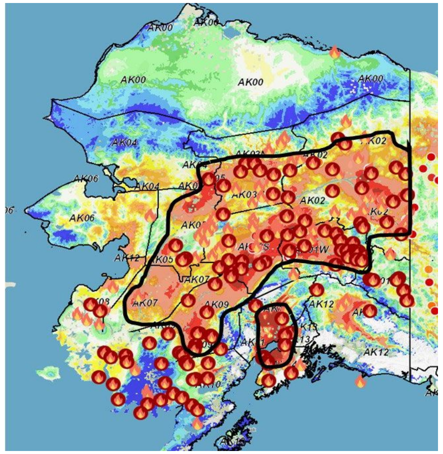
Wildfires and the Electricity Grid in Alaska

Alaska is vulnerable to wildfires:

- Fire-prone boreal forests
- Extreme fire behavior

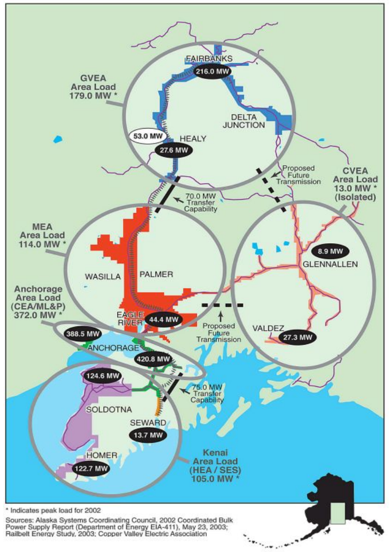
Alaska's electricity grid is unique:

- The electricity grid in Alaska is a patchwork of "microgrids" that supply power to relatively few households.
- Even the electric grid along Alaska's Railbelt is on its own "island" separated from the rest of the United States.
- The critical dependence of its rural communities on electricity for health and year-round food supply makes Alaska more vulnerable to power outages.

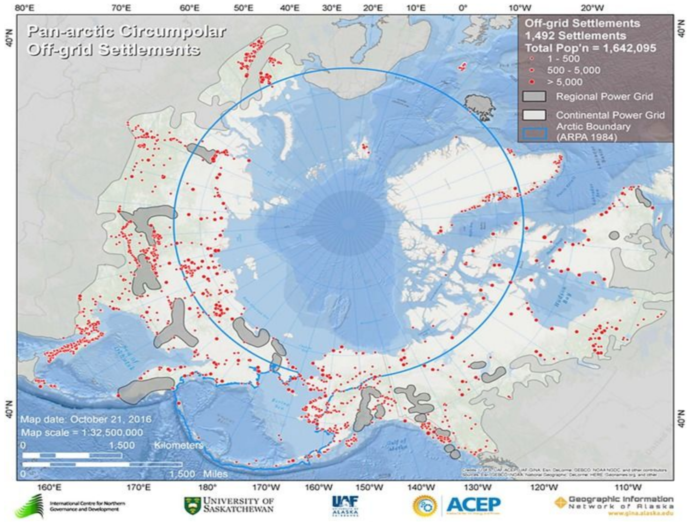


Alaska Wildland Fire Information, AKFIREINFO.COM

www.kinyradio.com/news/news-of-the-north



http://www.chugachconsumers.org/



(Gwen Holdmann and Poelzer et al. 2016), https://scholarworks.alaska.edu/handle/11122/11273

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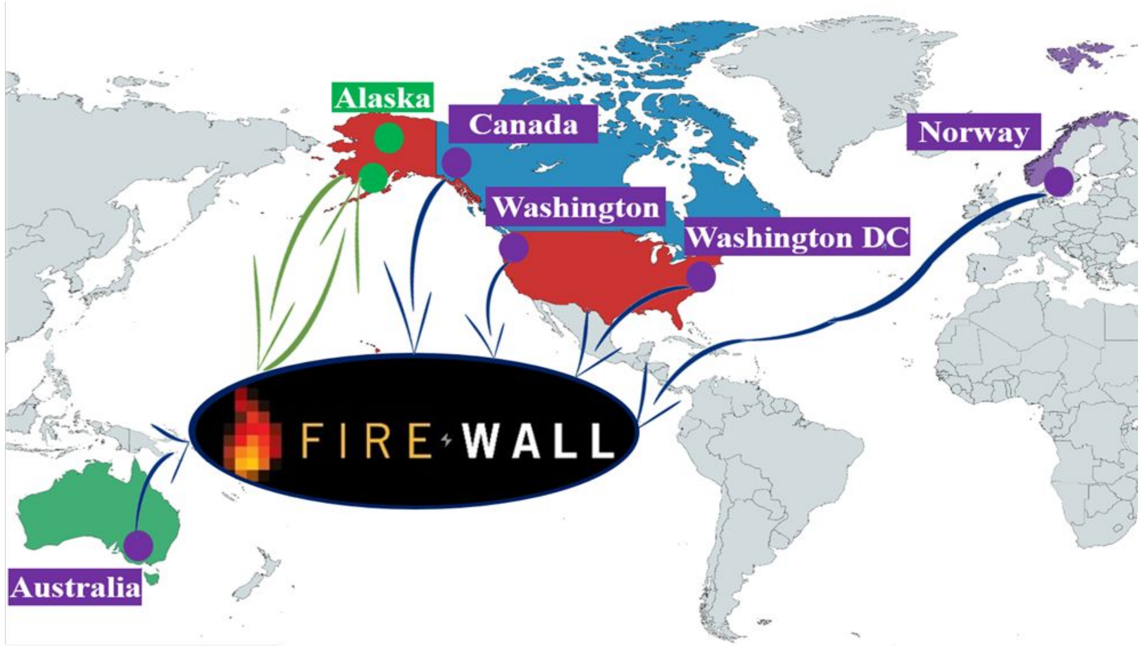
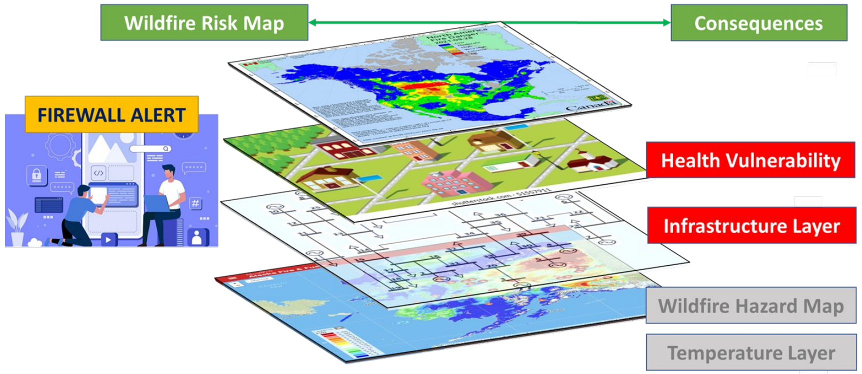


Built Environment	Natural Environment	Social Environment
How to make proactive decisions to prevent electrically-induced wildfires in Alaska?	What is the spatial distribution of fire-prone wildfire fuels (fuel classification) near electric utility assets?	What information do multi-sectoral stakeholders need to manage power outages in context of wildfires?
How to make informed decisions to mitigate the impacts of progressive wildfires?	How can static environmental variables & real-time fire weather help characterize fire danger and risk?	What actionable social vulnerability metrics can be integrated into the FIREWALL platform?
How to enable cross-sector longer-term planning decisions for resilience to future wildfires?	What modeling approach is most suitable for a near real-time assessment and prediction of fire spread?	How can the FIREWALL platform be used for collaborative decisions among stakeholders in Alaska?

FIREWALL ALERT:
An Interactive Platform for Informed and Coordinated Decision-Making



It is a collaborative effort…

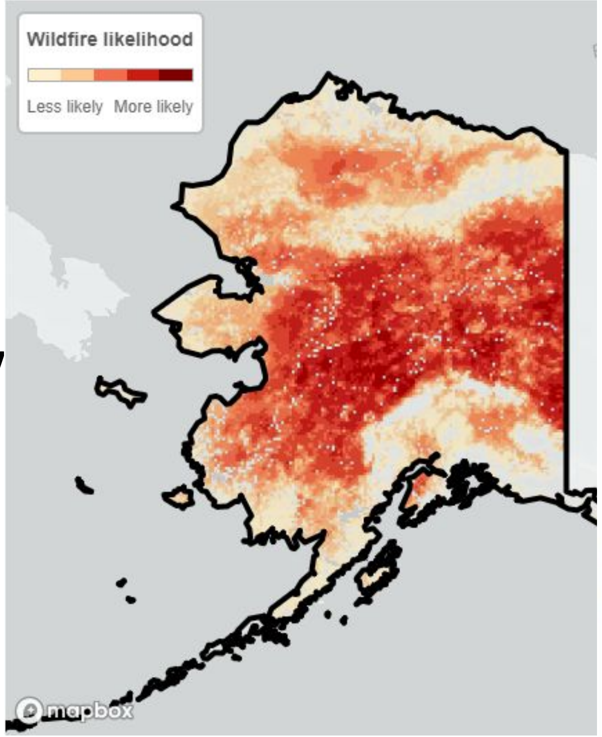
We need to see this problem from multiple perspectives. Stakeholders have various concerns, data and informational needs. We hope to:

- Improve communication and information sharing between stakeholders.
- Address the need for extensive data from diverse layers, encompassing both environmental and societal factors, to guide their strategic and operational decision-making.

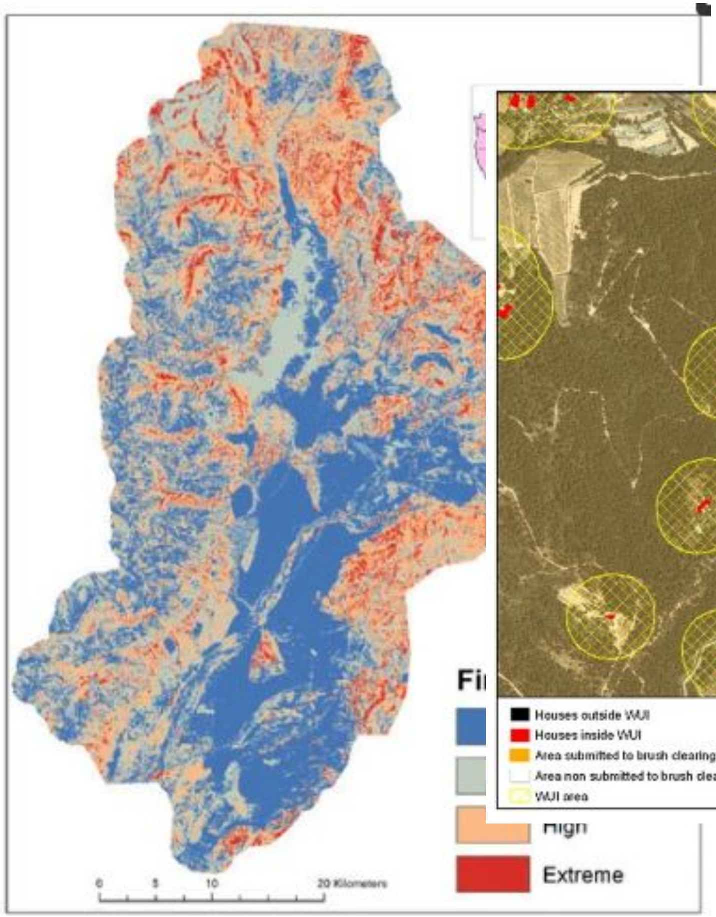
FIRE WALL

GIS and Community Level Wildfire Risk Assessment

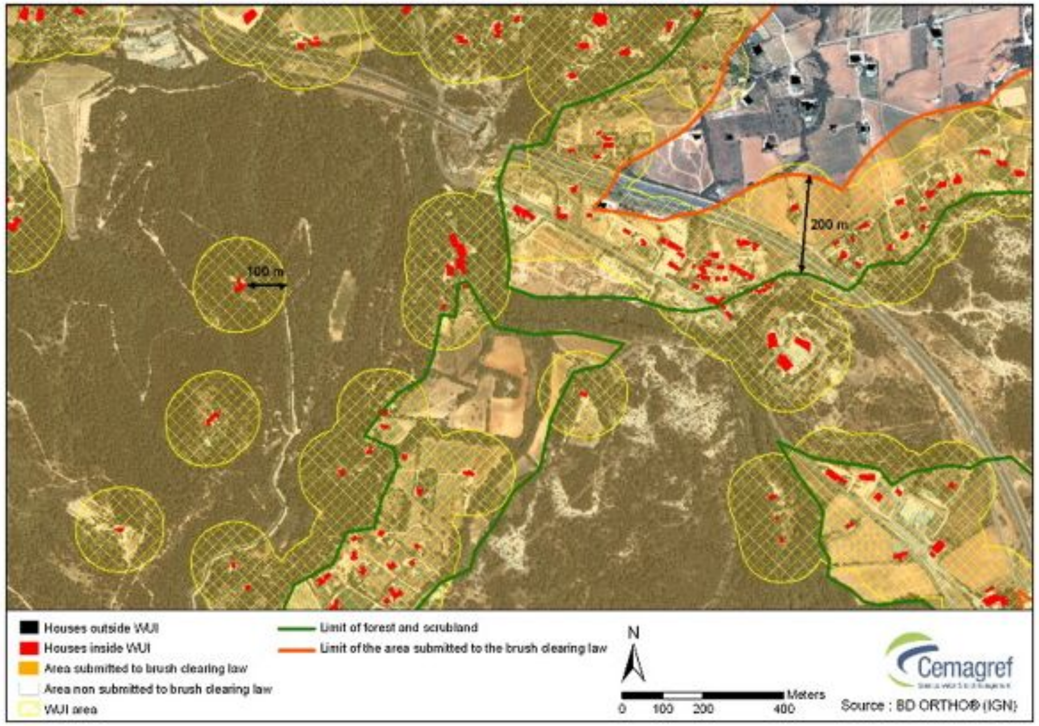
What is
Community Lev



Wildfire Risk to Communities ,USDA Forest Service
Wildfirerisk.org



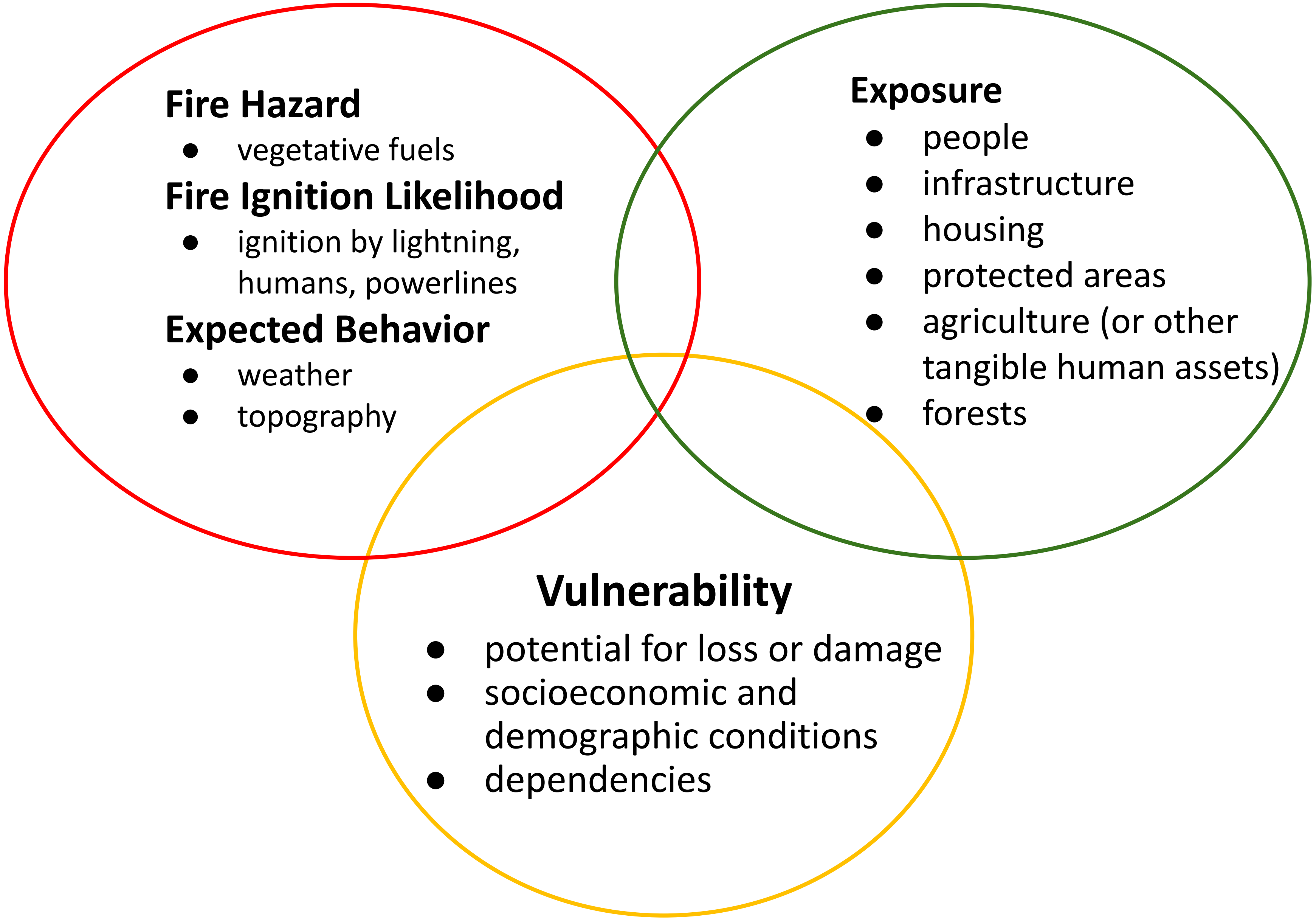
Szpakoski and Jensen https://doi.org/10.3390/rs11222638



Lampin-Maillet, Jappoit, Long, Bouillon, Morge, Ferrier
https://doi.org/10.1016/j.jenvman.2009.10.001

FIRE·WALL

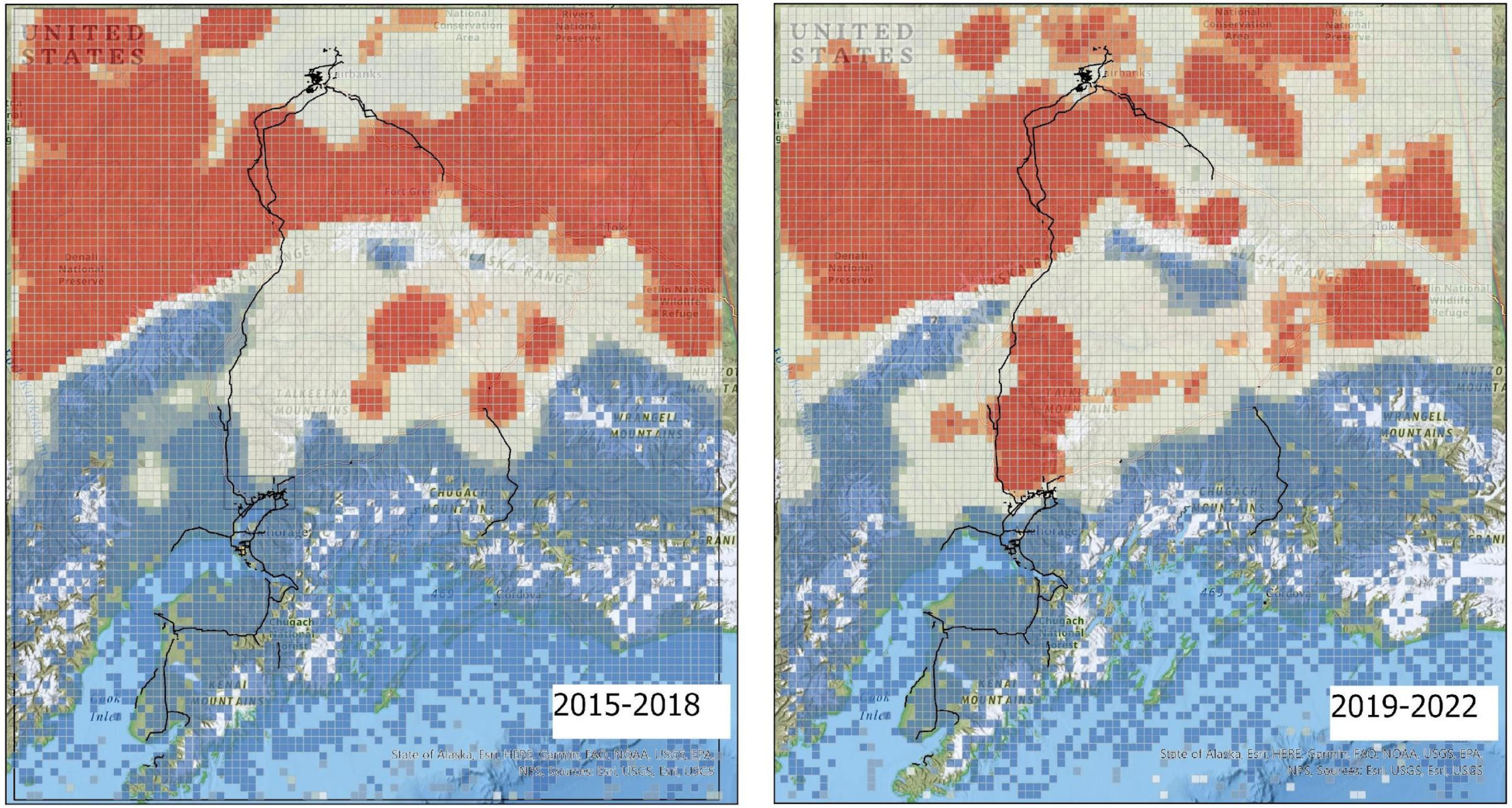
Risk Assessment for Wildfire in Communities



Preliminary Results:

Hot-spot analysis of cloud-to-ground lightning strikes

Fire Hazard: Lightning!



Electrical Lines
Cold Spot with 99% Confidence
Cold Spot with 95% Confidence
Cold Spot with 90% Confidence
Not Significant
Hot Spot with 90% Confidence
Hot Spot with 95% Confidence
Hot Spot with 99% Confidence

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Satellite Data and Wildfire Prediction

- Challenges: Alaska is a Unique Environment

- Existing models for predicting fire do poorly on Alaskan data
  - Diverse vegetation types and climates

- Due to Alaska‘s high latitude getting satellite data can be challenging
  - LANDSAT Satellites are in a nearly polar-orbit

FIRE WALL

Datasets: Canada

- Obtained from Kaggle in 2023
- 42,848 Images
  - 22,709 Wildfire
  - 20,139 No-Wildfire
- 350x350 Pixels
- Consists of medium/high resolution satellite imagery

No-Wildfire:

Wildfire:

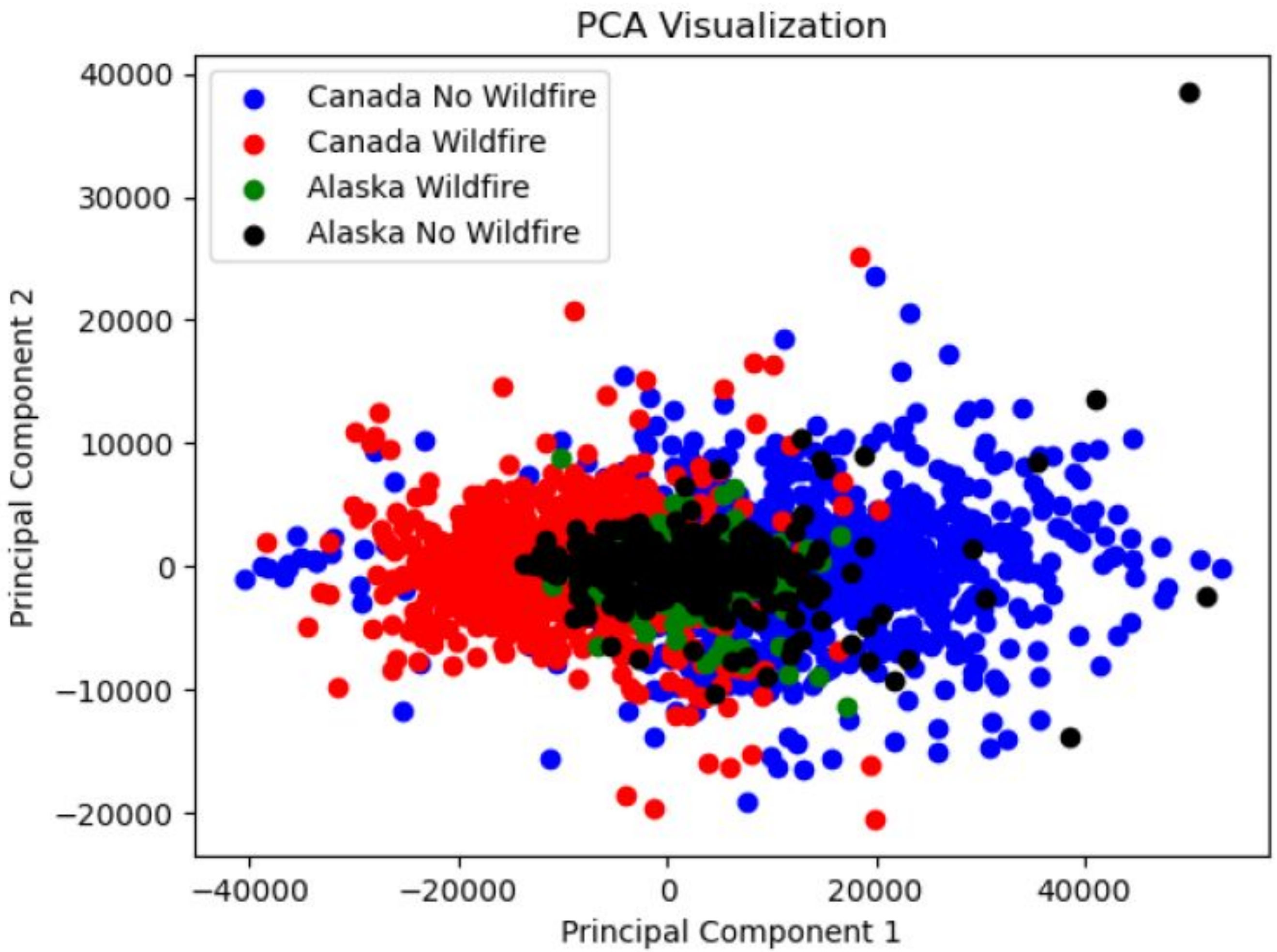
Datasets: Alaska

- Alaska Interagency Coordination Center (AICC)
  - Continuously update fire data
- 1,518 images
  - 1,079 Wildfire
  - 439 No-Wildfire
- 350x350 Pixels

No-Wildfire:

Wildfire:

Datasets: Comparison



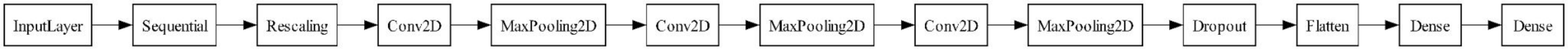
Models: Progression

- Widely used pre-trained models were tried first
  - 50-60 % accuracy on Alaska Data and 80-96% on Canadian Data
- Logistic Regression
  - 30% accuracy on Alaska Data and 89% on Canadian Data
- MLP model
  - 30% accuracy on Alaska Data and 89% on Canadian Data
- Custom CNN
  - 75% accuracy on Alaska Data and 98% on Canadian Data

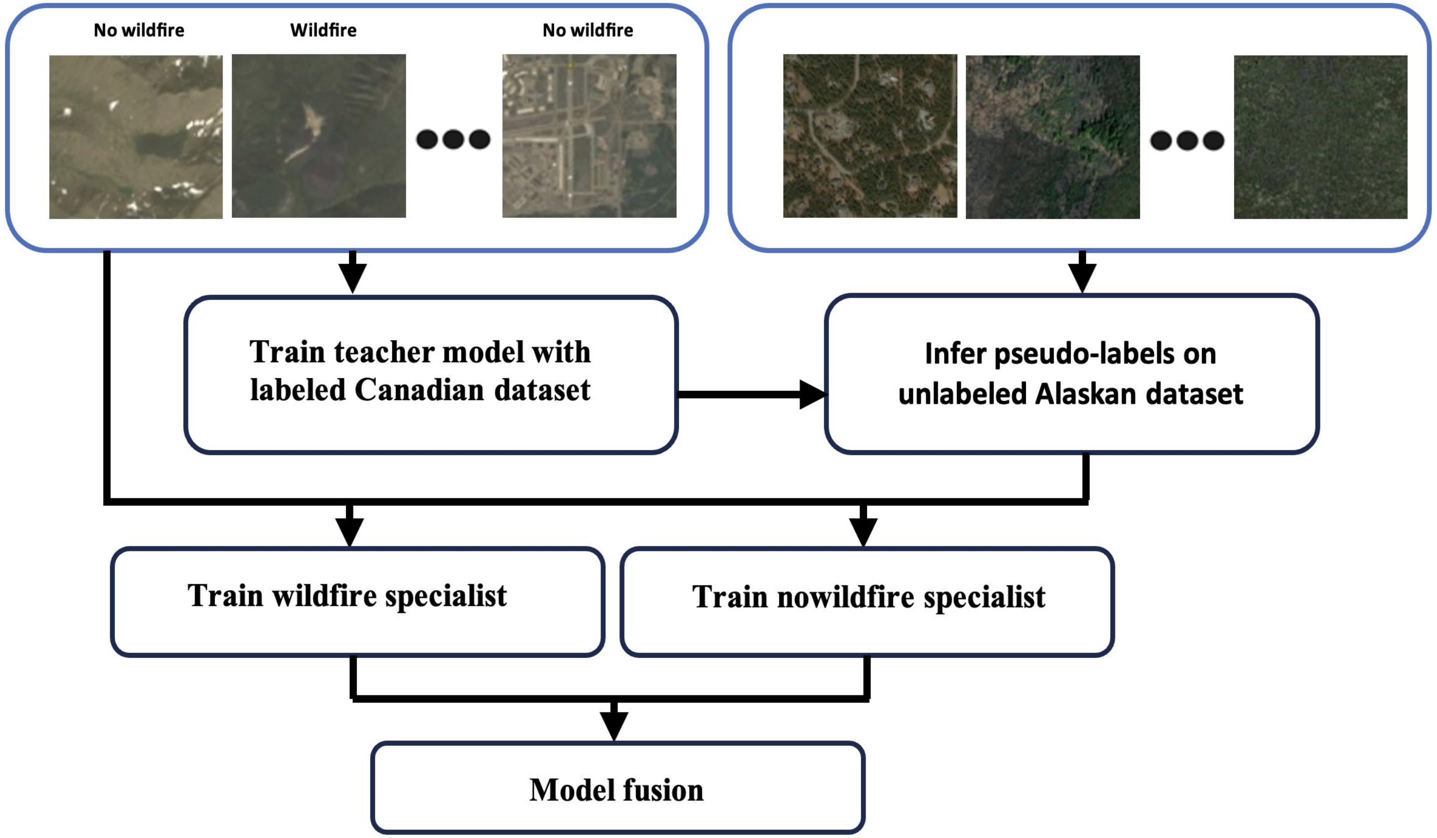
Models: Custom CNN (CNN1)

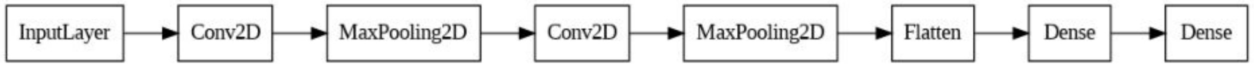
- Did very well on Canadian Data
  - Accuracy = 98.40%
  - F1 Score = 97.81%

- Not so well on Alaska Data
  - Accuracy = 75.60%
  - F1 score = 70.17%



Models: Teacher Student Model Fusion





Models: Teacher Student Model Fusion

Labeled images $D_t = \{(x_1, y_1), (x_2, y_2), ..., (x_n, y_n)\}$ and unlabeled images $D_s = \{\tilde{x}_1, \tilde{x}_2, ..., \tilde{x}_m\}$

$\theta^* \leftarrow$ Adam $(\frac{1}{n}\sum_{i=1}^{n} loss(y_i, f_t(x_i, \theta)))$

Generate pseudolabels for D_s using f_t :

$$\tilde{y}_i \leftarrow f_t(\tilde{x}_i, \theta^*)\ \forall i = 1, ..., m$$

Combine labeled dataset D_t with pseudo-labeled dataset D_s to create combined datasets D_cs:

$D_{c_1} \leftarrow D_s \cup D_{t_1} = \{(x_i, y_i) \mid (x_i, y_i) \in D_t, y_i = \text{“}Wildfire\text{”}\}$

$D_{c_2} \leftarrow D_s \cup D_{t_2} = \{(x_i, y_i) \mid (x_i, y_i) \in D_t, y_i = \text{“}Nowildfire\text{”}\}$

$\theta^*_{s_j} \leftarrow$ Adam $(\frac{1}{n}\sum_{(x_i,y_i)\in D_{c_1}} loss(y_i, f_t(x_i, \theta_{s_j}))$, $j = 1, 2)$

for each $(x_i, y_i) \in D_c$ **do** ▷ Model fusion

    if $f_{s_1}(x_i, \theta^*_{s_1}) \neq f_{s_2}(x_i, \theta^*_{s_2})$ **then**

        $p_1 \leftarrow f_{s_1}(x_i, \theta^*_{s_1})$ ▷ p stands for posterior probability

        $p_2 \leftarrow f_{s_2}(x_i, \theta^*_{s_2})$

        $p_{\hat{y}_i} \leftarrow \alpha \cdot p_1 + (1 - \alpha) \cdot p_2$

    else

        $\hat{y}_i \leftarrow f_{s_1}(x_i, \theta^*_{s_1})$

    end if

end for

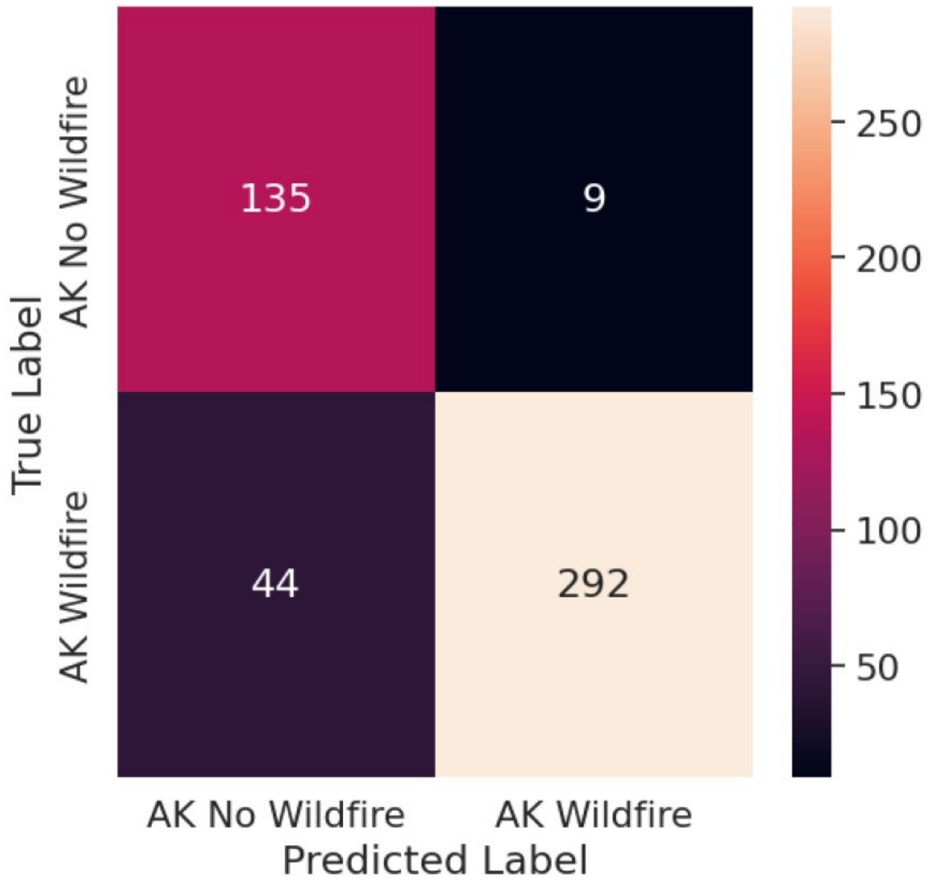
Experimental Results

Method	Canada data	Alaska data
LR	88.90	30.40
MLP	89.40	30.10
VGG19 [31]	94.64	51.23
ResNet-50 [32]	95.84	50.00
MobileNet [33]	96.14	59.67
EfficientNet-B4 [34]	79.96	60.89
EfficientNet-B7 [34]	85.43	58.12
CNN1	**98.40**	**75.60**
Teacher model	**94.23**	**72.23**

Model Configuration	Accuracy (%)	F1-Score (%)	Precision (%)	Recall (%)
CNN1 (Teacher) + 1 CNN1 (Student)	81.59	87.81	81.12	94.32
CNN1 (Teacher) + 2 CNN1 (Students) + Fusion	81.87	85.13	100	74.19
Teacher Model + 1 Student	83.42	84.40	83.42	86.60
Teacher Model + 2 Students + Fusion (the proposed model)	**88.96**	**91.68**	97.00	86.90

Experimental Results

Could we improve the model further?



Could we improve the model further?

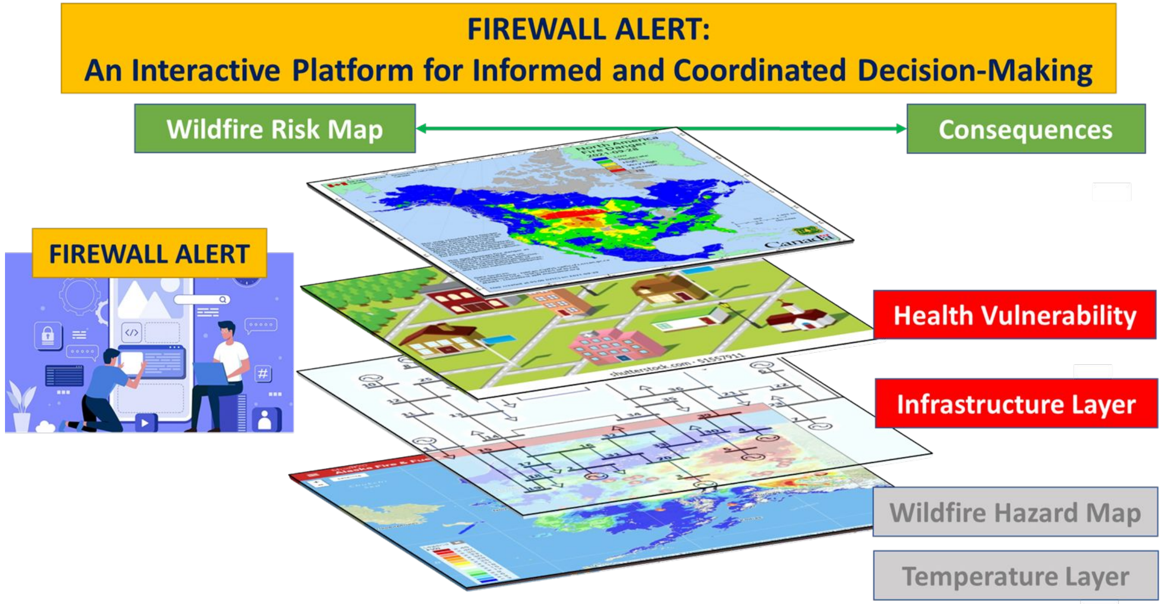
- The results of our study highlight the effectiveness of our proposed model in improving wildfire prediction capabilities in challenging geographical locations.
- Move to multispectral

Pre-Fire

Post-Fire

Future work

✔ Integration of GIS, remote sensing, data analysis and interview results



Thank You!

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