NIST Fences Research and Findings

NIST WUI Fire Days 2022

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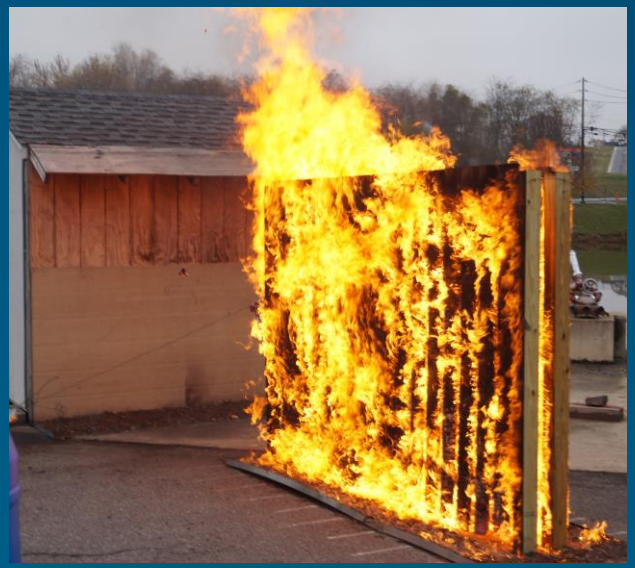

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NIST Technical Note 2228

Wind-Driven Fire Spread to a Structure from Fences and Mulch

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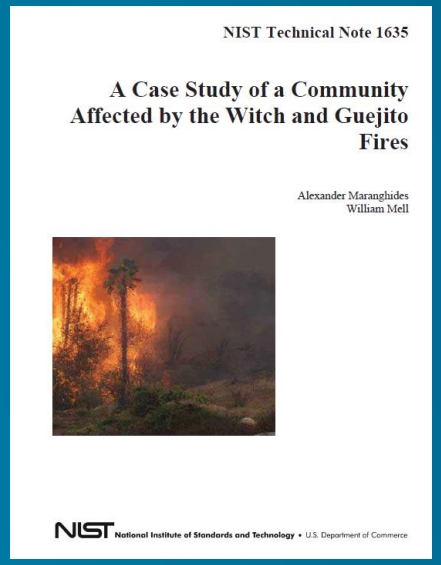
Introduction

How Does Fire Spread in the WUI?

- Direct Flame Contact
- Radiation
- Firebrands (Embers)

https://ihrsq.wordpress.com/2015/11/09/land-use-as-a-tool-for-reducing-wui-fire-risk/

WUI Fire Case Studies – NIST Collaborations


NIST Technical Note 1635

A Case Study of a Community Affected by the Witch and Guejito Fires

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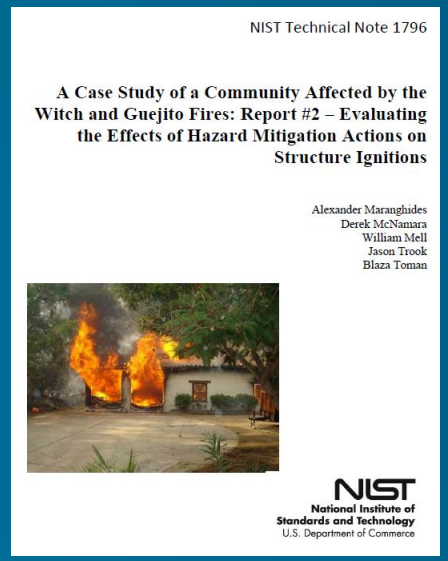
NIST Technical Note 1796

A Case Study of a Community Affected by the Witch and Guejito Fires: Report #2 – Evaluating the Effects of Hazard Mitigation Actions on Structure Ignitions

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Blaza Toman

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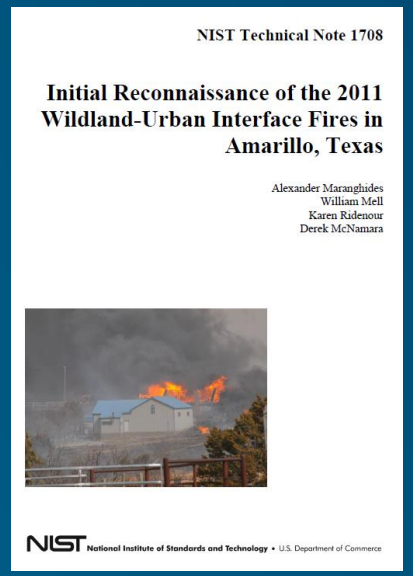
Amarillo fires
2011, TX

Witch-Guejito fires
2007, CA


NIST Technical Note 1708

Initial Reconnaissance of the 2011 Wildland-Urban Interface Fires in Amarillo, Texas

Alexander Maranghides
William Mell
Karen Ridenour
Derek McNamara

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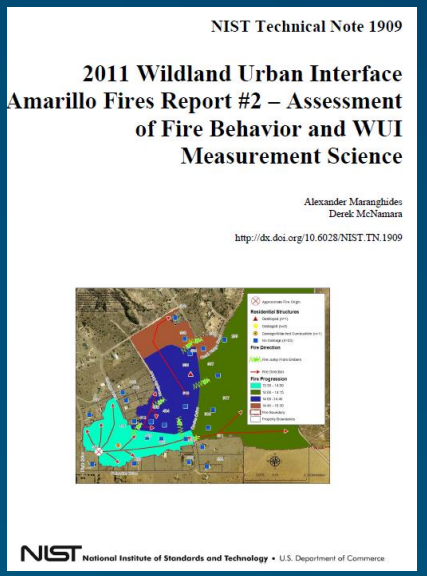
NIST Technical Note 1909

2011 Wildland Urban Interface Amarillo Fires Report #2 – Assessment of Fire Behavior and WUI Measurement Science

Alexander Maranghides
Derek McNamara

http://dx.doi.org/10.6028/NIST.TN.1909

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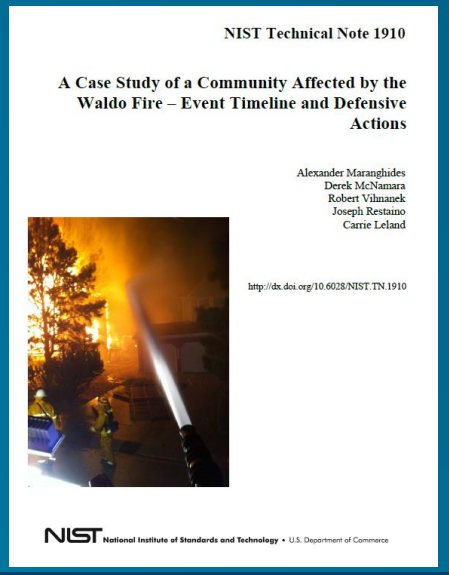
Waldo Canyon fire
2012, CO


NIST Technical Note 1910

A Case Study of a Community Affected by the Waldo Fire – Event Timeline and Defensive Actions

Alexander Maranghides
Derek McNamara
Robert Vihnanek
Joseph Restaino
Carrie Leland

http://dx.doi.org/10.6028/NIST.TN.1910

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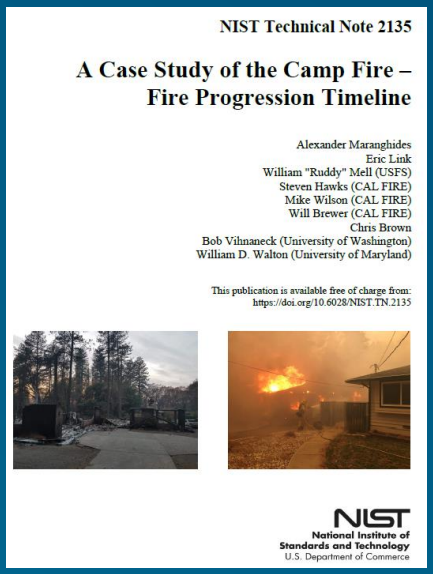
Camp Fire
2018, CA


NIST Technical Note 2135

A Case Study of the Camp Fire – Fire Progression Timeline

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William "Ruddy" Mell (USFS)
Steven Hawks (CAL FIRE)
Mike Wilson (CAL FIRE)
Will Brewer (CAL FIRE)
Chris Brown
Bob Vihnaneck (University of Washington)
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Structure Vulnerability

- Flame Spread + Firebrand Generation
  - Detached Combustibles
    - Mulch Beds / Ground Cover
    - Fences
    - Woodpiles
    - Landscape Timbers / Railroad Ties
    - Sheds, gazebos, playsets

Fences as Pathways for Fire Spread

- Provide a pathway for direct flame spread
  - "House–fence–house–fence–house"
- Act as sources of firebrands
- Use firefighter resources

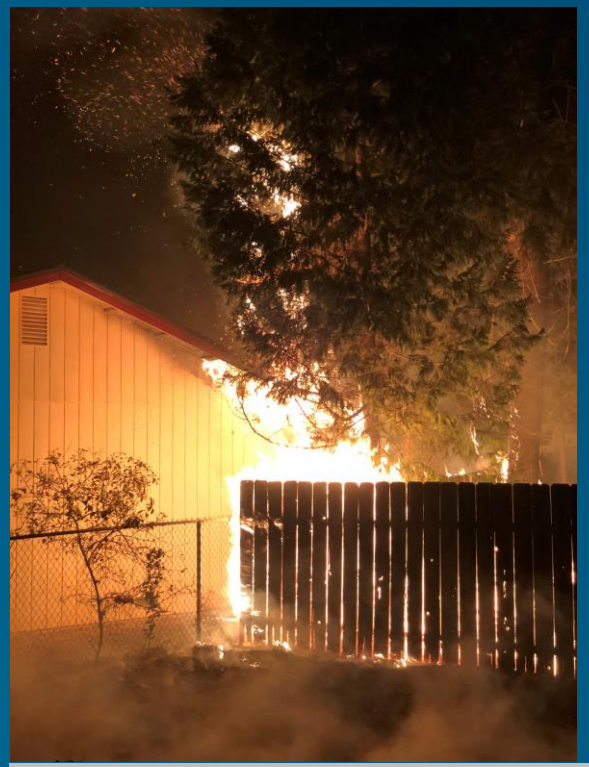

NIST – 2011 Amarillo fires

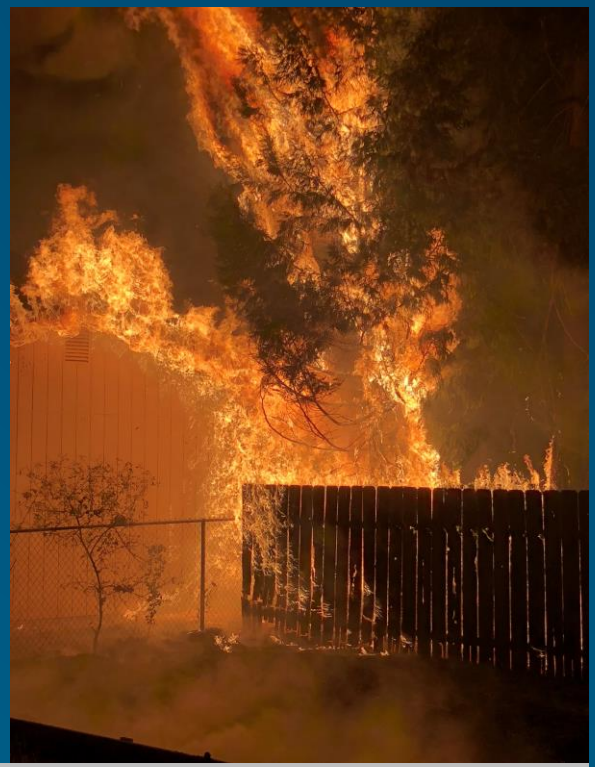

Colorado Springs Fire Department – 2012 Waldo Canyon fire

Fences as Pathways for Fire Spread

2018 Camp Fire

Photo courtesy of American Medical Response (AMR) – Shasta County, used with permission





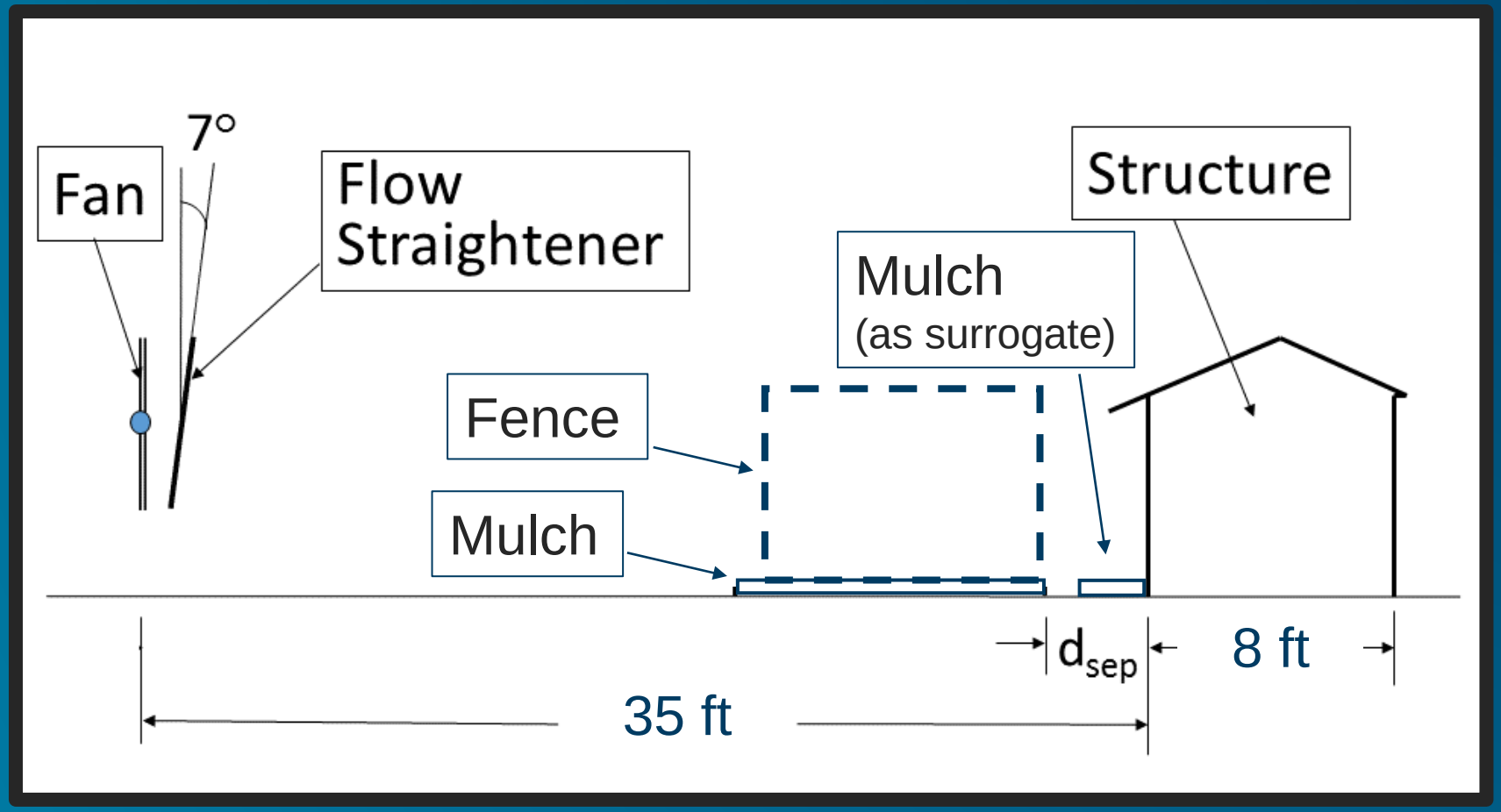
Photos courtesy of CAL FIRE, used with permission

Objectives of This Work

- Confirm the hazard
- Quantify the hazard under realistic conditions
- Identify and develop ways to mitigate the hazard

Experimental Design

Experimental Design

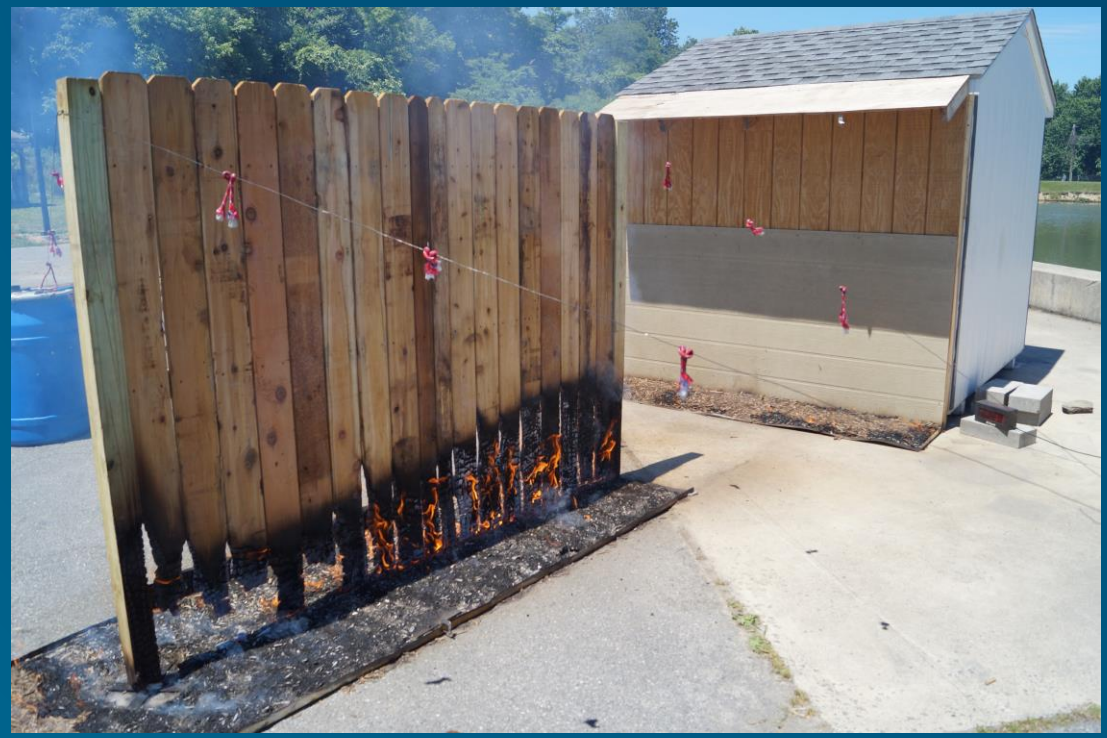


Experimental Site

- Frederick County Fire & Rescue Training Facility

Experimental Setup

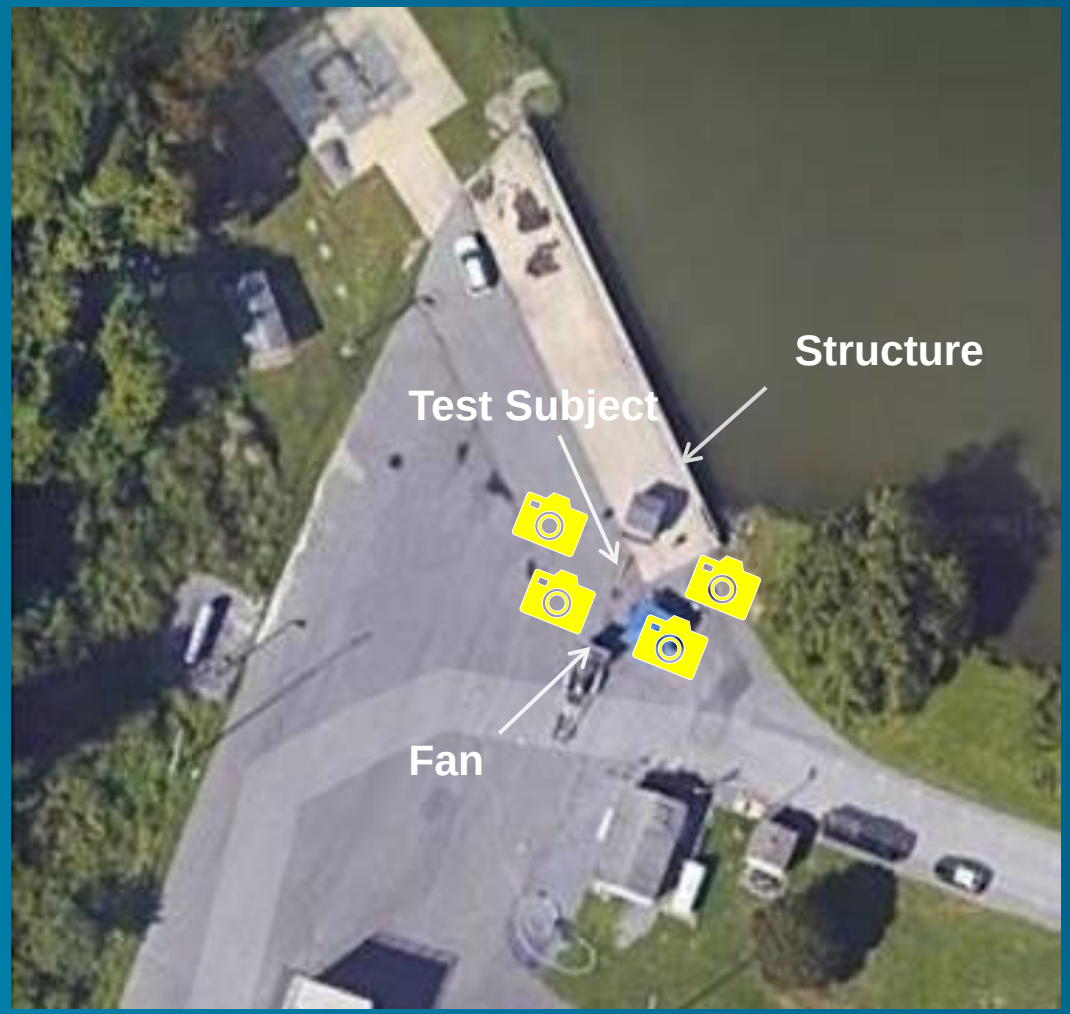
Fan + Flow Straightener

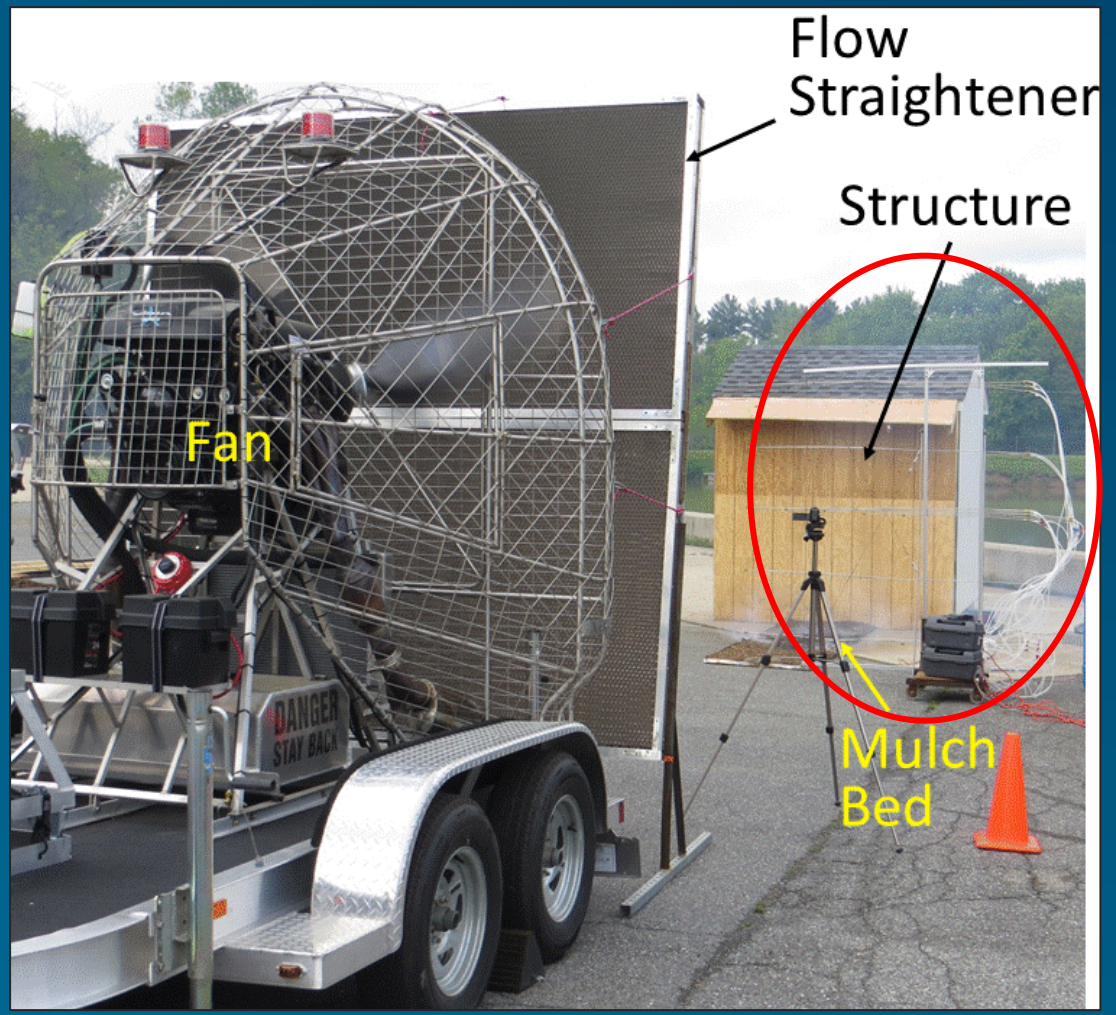


Fence + Mulch being tested

Structure (shed) + mulch at base

Experimental Setup





Experimental Setup – Fence Test

Variables

- Mulch Type: Material
- Fence Type: Material and design
- Configuration: Combinations of fences and mulch
- Wind Speed
- Separation Distance

Mulch Types: Materials

Shredded Hardwood

Pine Bark Mulch

Artificial Turf
(PP fibers with urethane backing)

Pine Straw Mulch

Rubber Mulch

Fence Types: Materials and Designs

Privacy

- Western redcedar
- Aged
- Vinyl



Lattice

- Redwood
- Pine


Good Neighbor

- Western redcedar

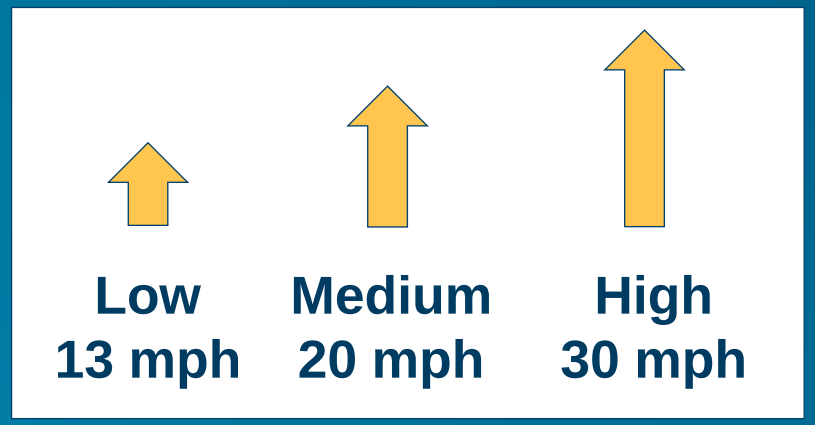
Privacy: Wood-Plastic Composite

- WPC1
- WPC2


Variables

- Configuration: Mulch/fence alone or in combination
  Parallel fences
  No structure (long-range firebrands)

- Wind Speed



- Separation Distance

Limitations

- Few experiments are repeated
- Many fire processes are random
  - Ember generation
  - Ember ignition
  - Wind turbulence
- Fence, mulch, or combination is ignited in one location
- Most tests are single panel length
- Maryland weather conditions

Therefore, this is a survey → Trends, key hazards

Methodology

Experimental Procedure

Timing (in minutes)

- 0:00 – Wind data collection begins, cameras on
- 1:00 – Propane burners ignited
- 2:30 – Fan on (t = 0)
- End of Test
  - Flame spread to end of fence
  - Spotting to shed

Example: Fence + Mulch

Evidence of a vortex near wall

NIST Fire Dynamics Simulator (FDS) - Wind

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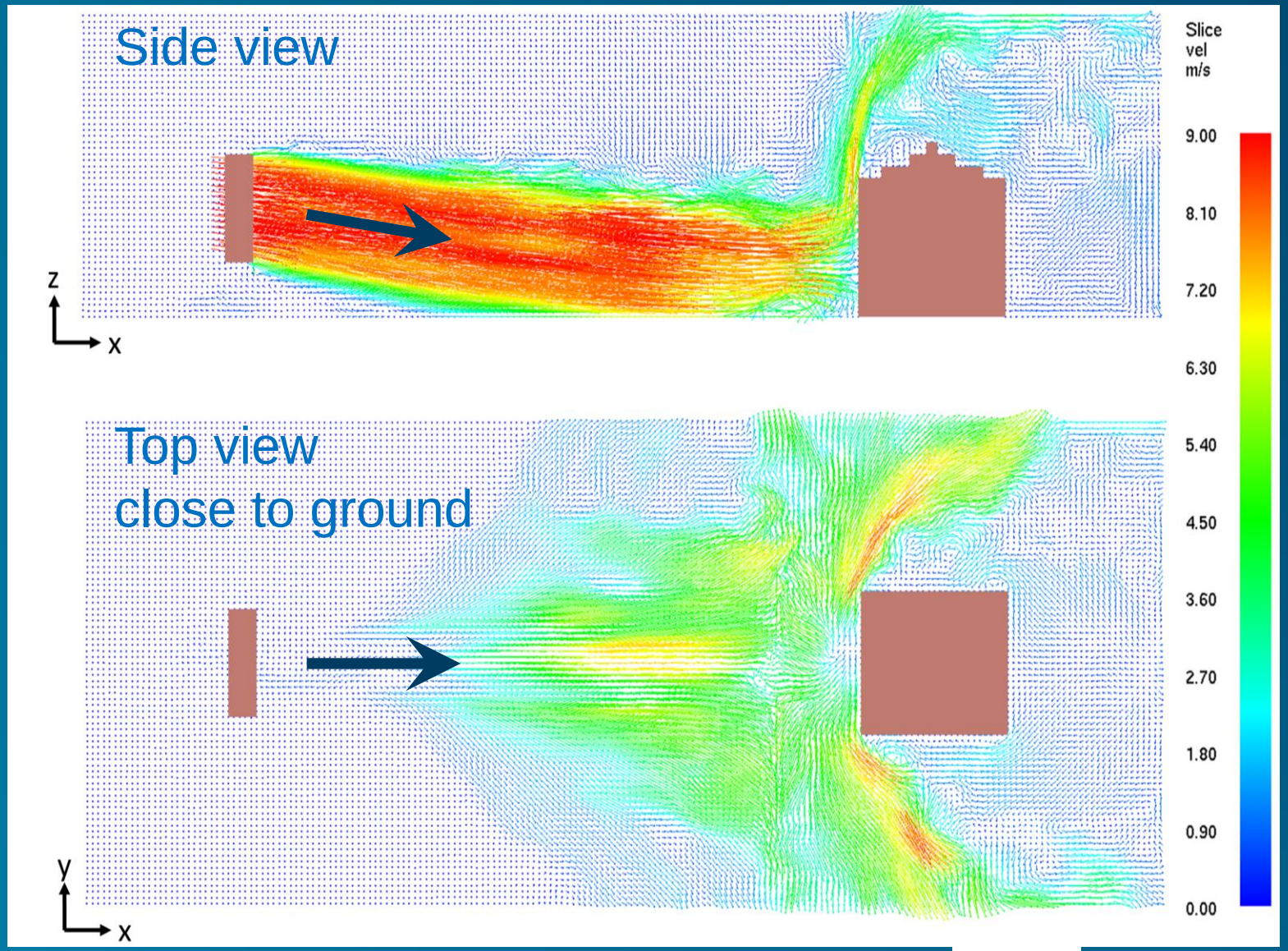

FDS - Wind

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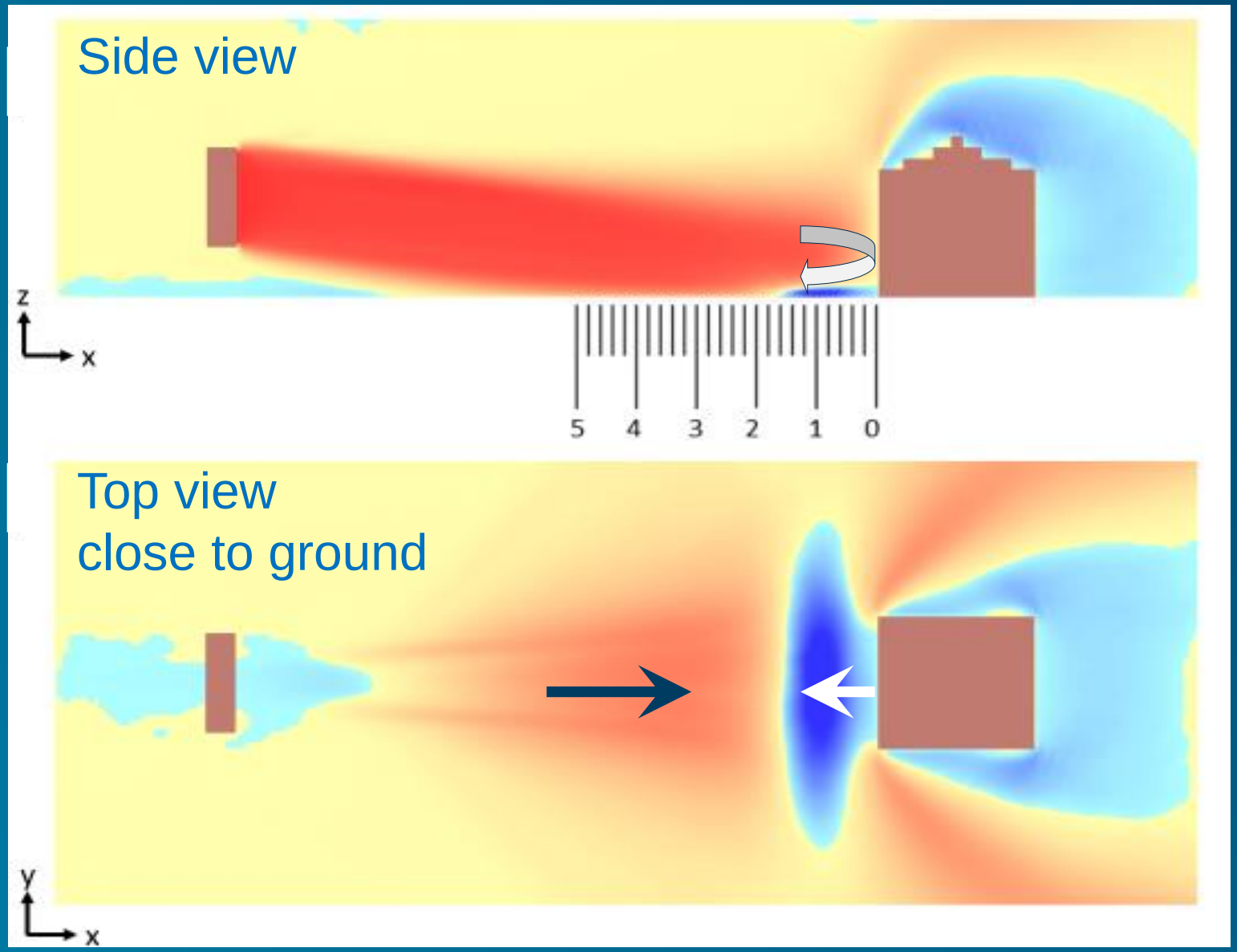


Experiments

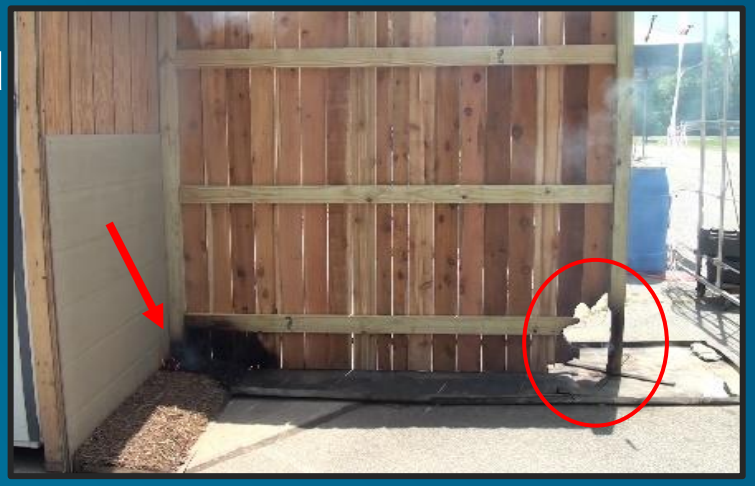
Experimental Configurations

Parallel Fences + Mulch

Experiments: Fence Only

Experiments: Fence Only

- Little spread
- Spotting to shed
  - May occur at higher wind speeds
  - Rare at low wind speed



Fence Only Exception: Wood-Plastic Composite #1

Fence Only Exception: Wood-Plastic Composite #1

6 ft tall burning boards fell to sides and forward of fence

Experiments: Mulch Only

Shredded Hardwood Mulch

- Slow/moderate horizontal spread
  - 10 min to 1 hr+ / test
- Flame spread via ember spotting
- Spotting to shed



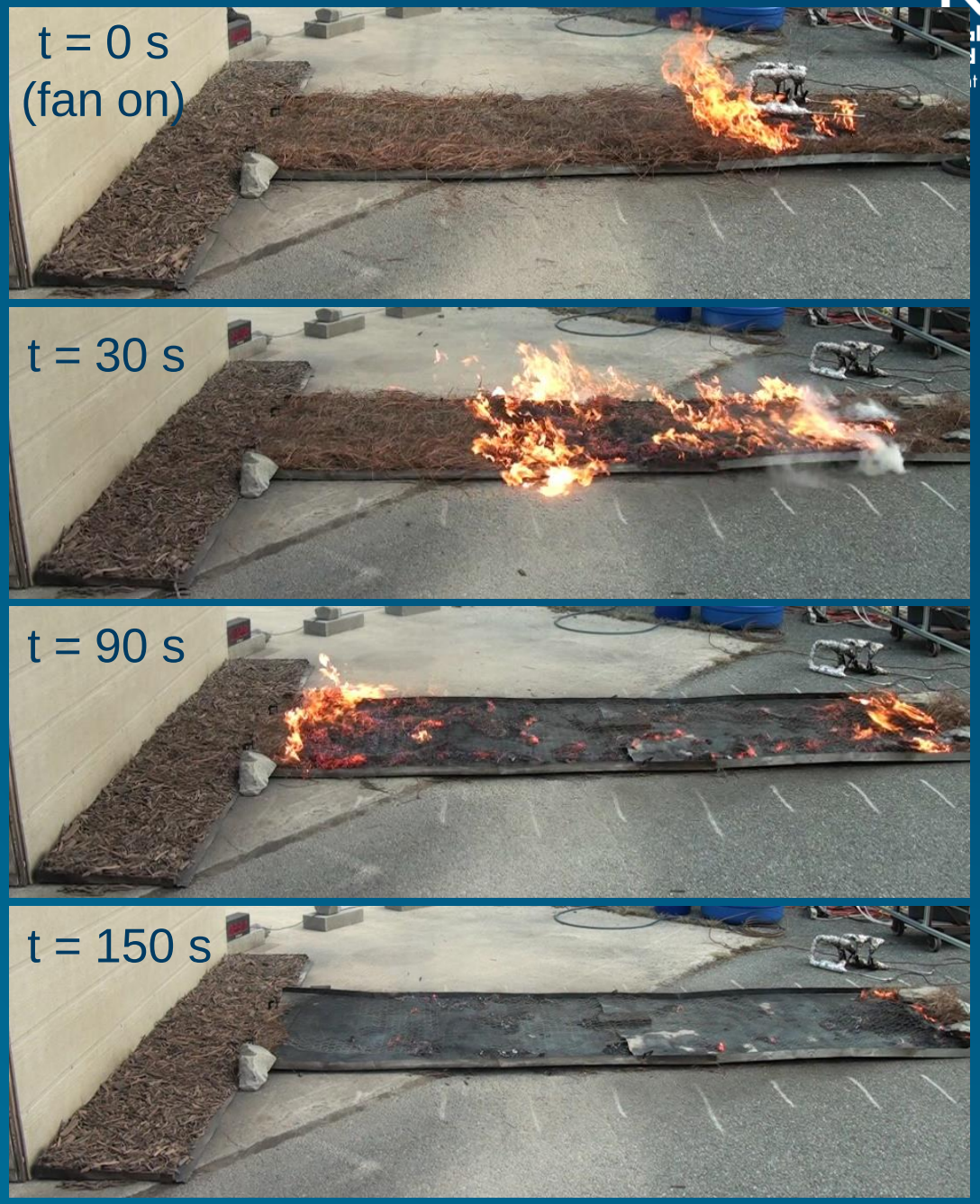

Pine Bark Mulch

- Slow/moderate horizontal spread
  - 10 min to 1 hr+ / test
- Flame spread via ember spotting
- Spotting to shed

Pine Straw Mulch

- Burns rapidly and intensely
  - Fine fuel is consumed completely
  - Over in a few minutes*
- Burns continuously – no ember spotting along length
- No spotting to shed

* …when not in contact with other combustibles

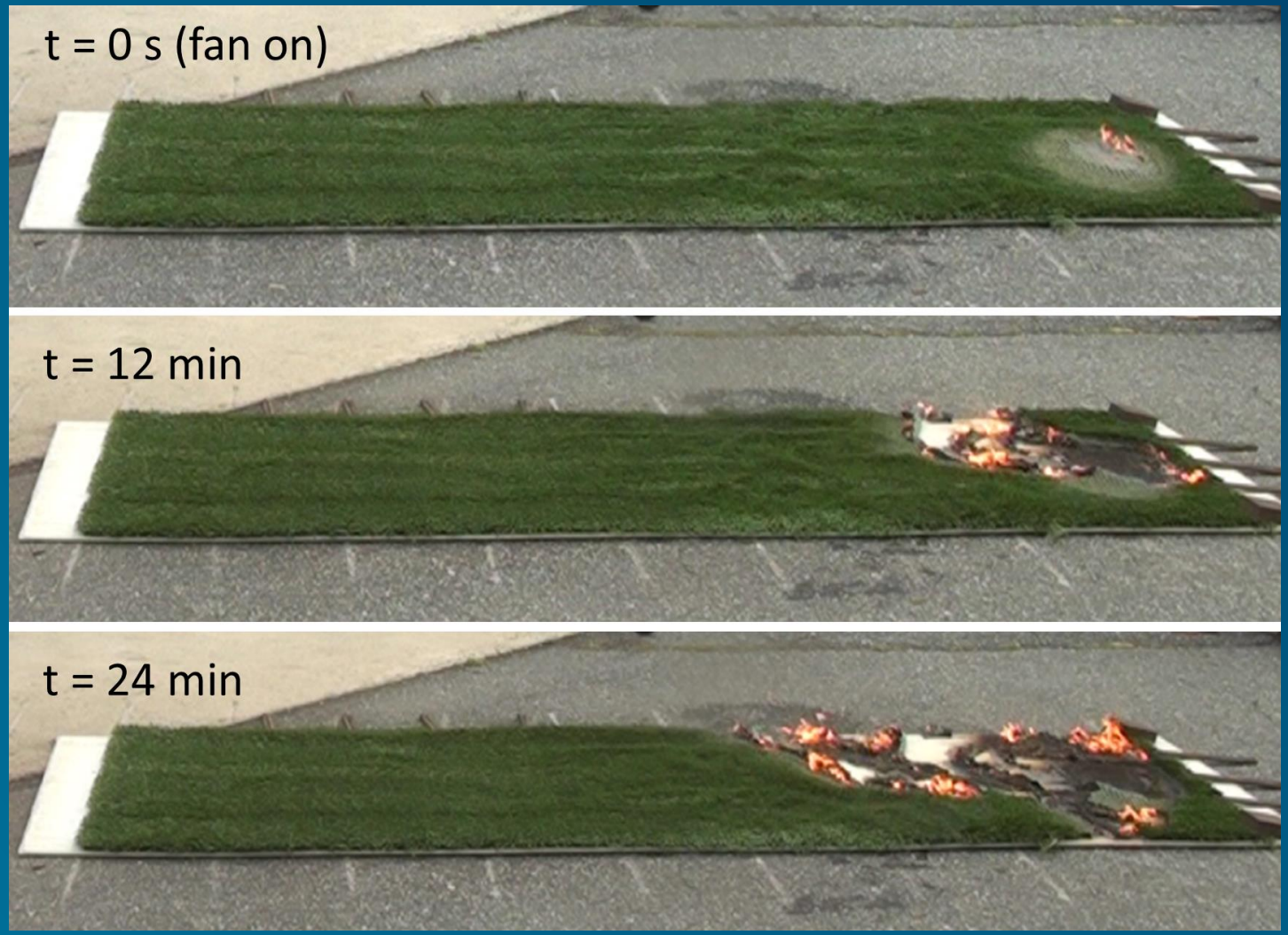


Rubber Mulch

- Burns with high initial intensity and toxic smoke
- Creates a top layer of pellets
- Sporadic burning continues for a long time
- Spotting to shed

Artificial Turf (PP fibers, urethane backing)

- Difficult to ignite
- Slow fire spread
- No spotting

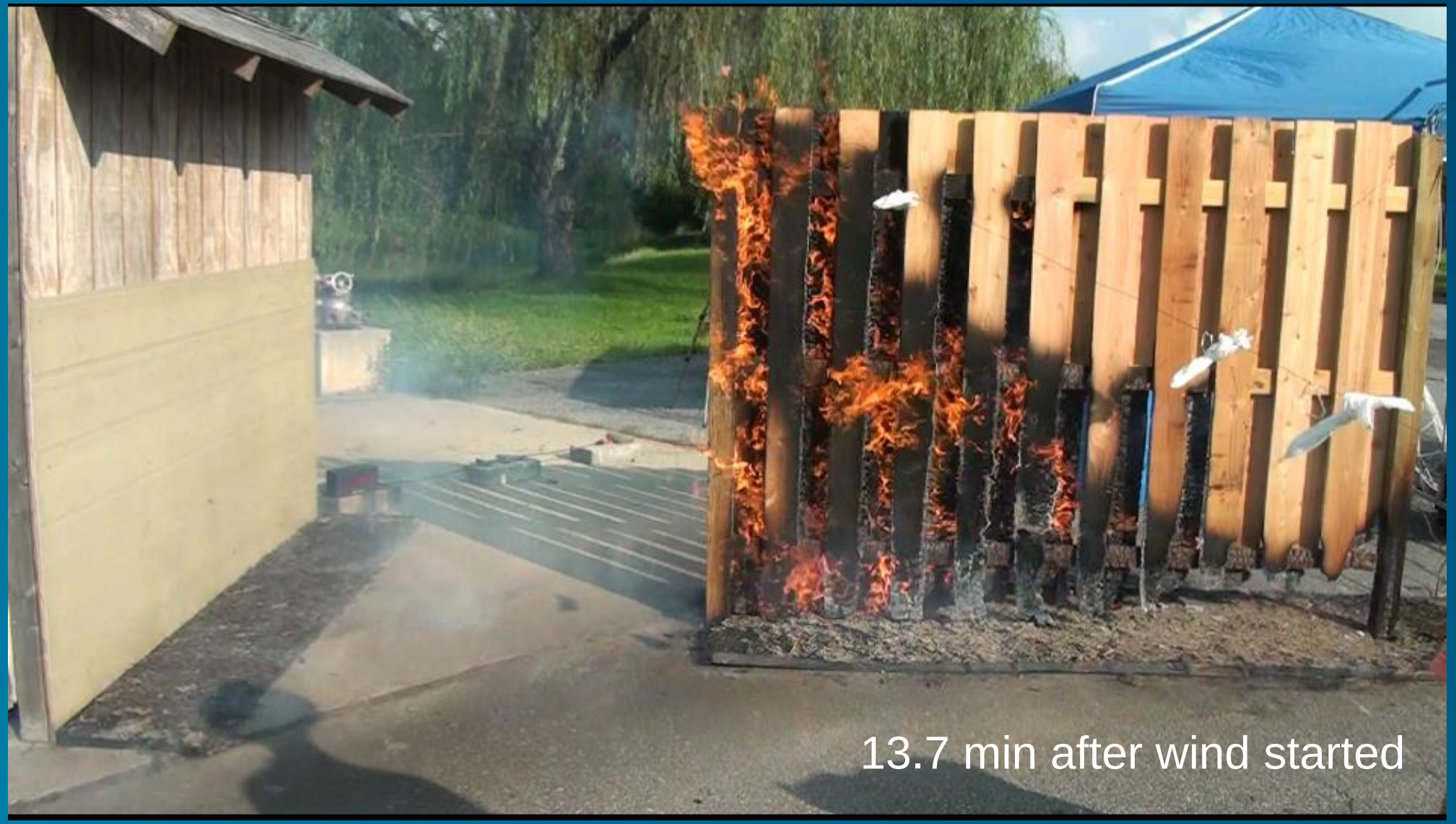


Experiments: Fence & Mulch

W. Redcedar Privacy Fence & Hardwood Mulch

- Moderate/fast horizontal spread
  - 8-20 minute test duration
  - Steady horizontal spread rate
- Spotting to shed

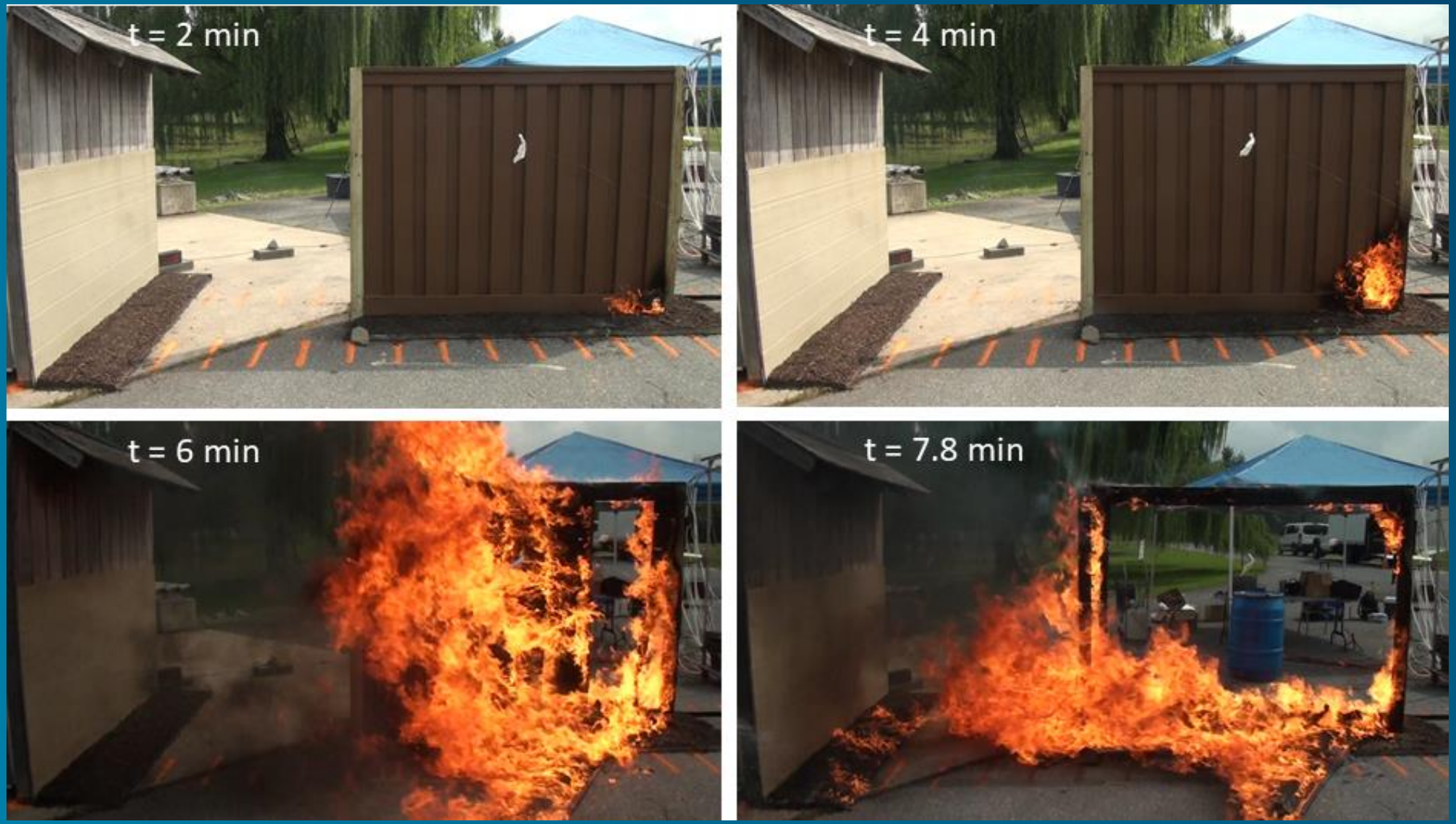
Good Neighbor Fence & Hardwood Mulch



W. Redcedar Privacy Fence & Pine Straw Mulch

Ember spotting occurs in 4 ½ min

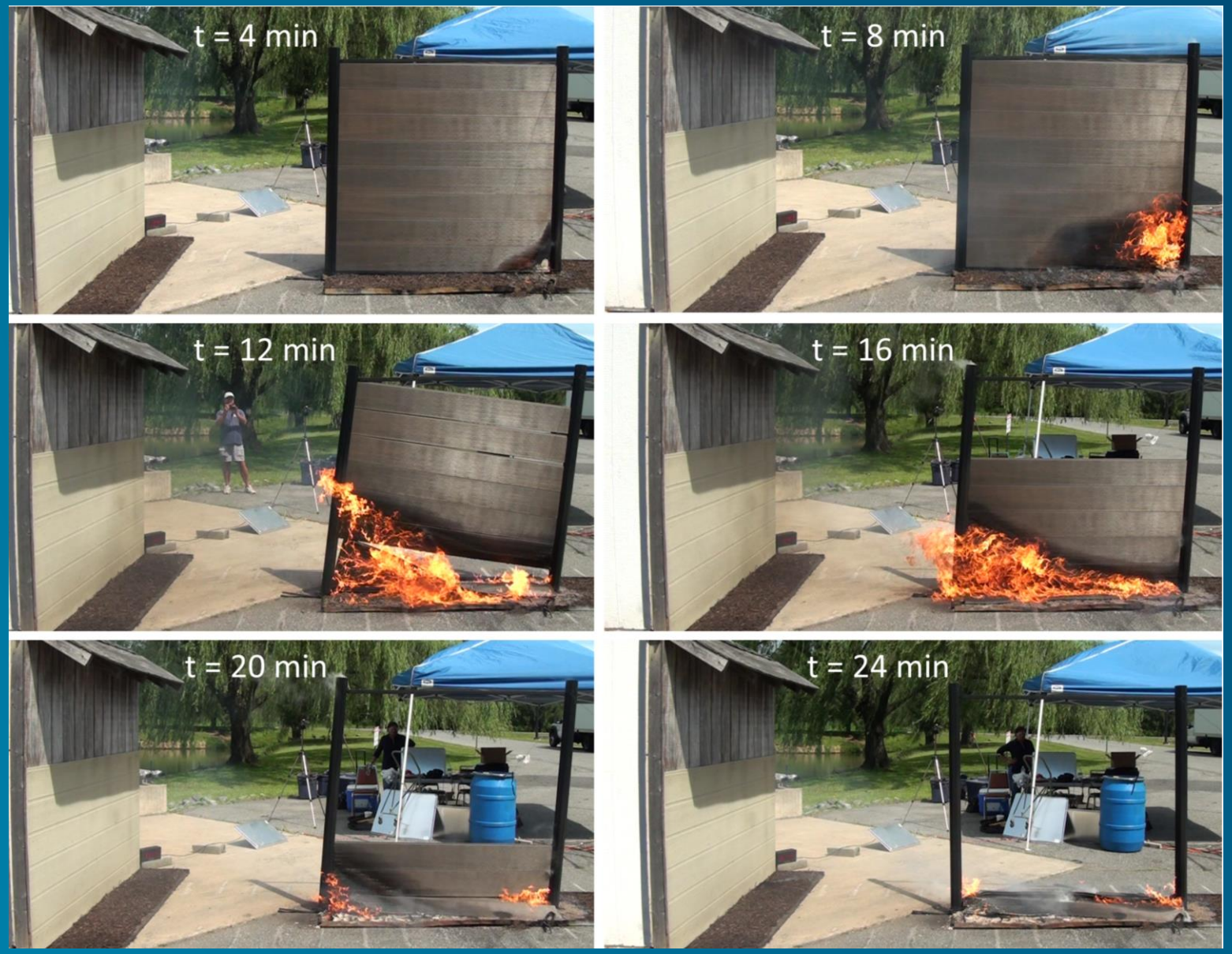
Wood-Plastic Composite Fence #1



Wood-Plastic Composite Fence #1

6 ft tall burning boards fell to sides and forward of fence

Wood-Plastic Composite Fence #2



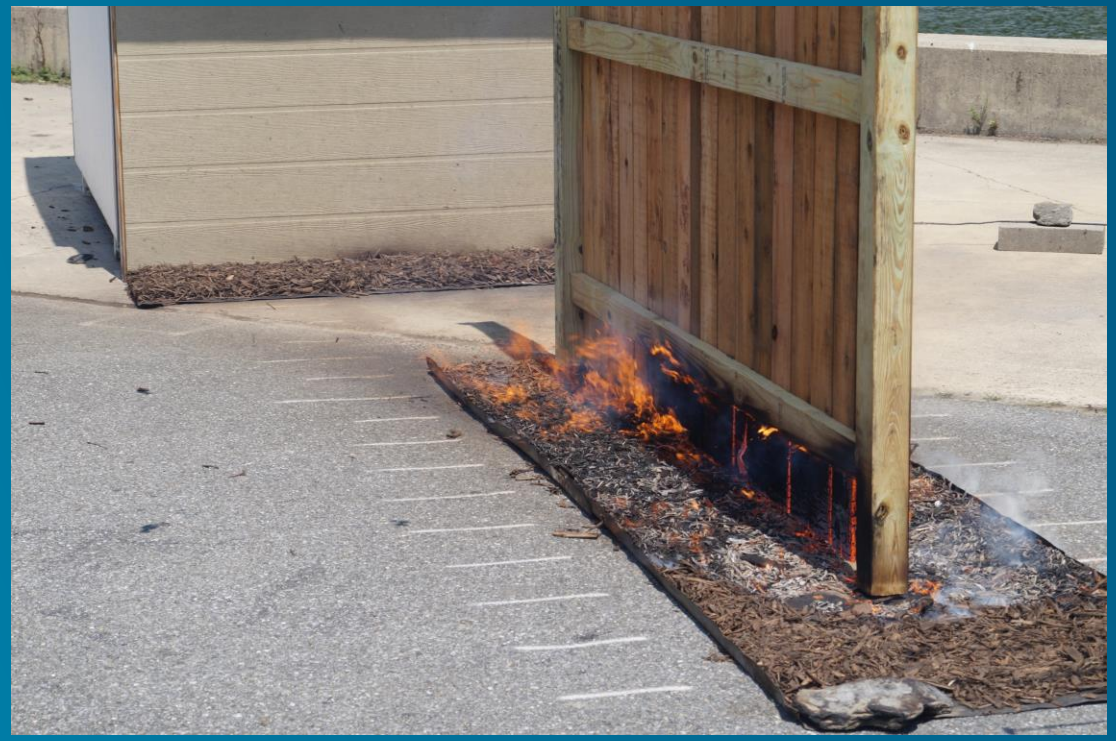
Fence design makes a difference

Experiments: Parallel Fences

Two Experiments Under Identical Conditions

Western Red Cedar Privacy Fence
Hardwood Mulch
6 ft separation distance
13 mph wind speed

Two Experiments Under Identical Conditions



Western Red Cedar Privacy Fence
Hardwood Mulch
6 ft separation distance
13 mph wind speed

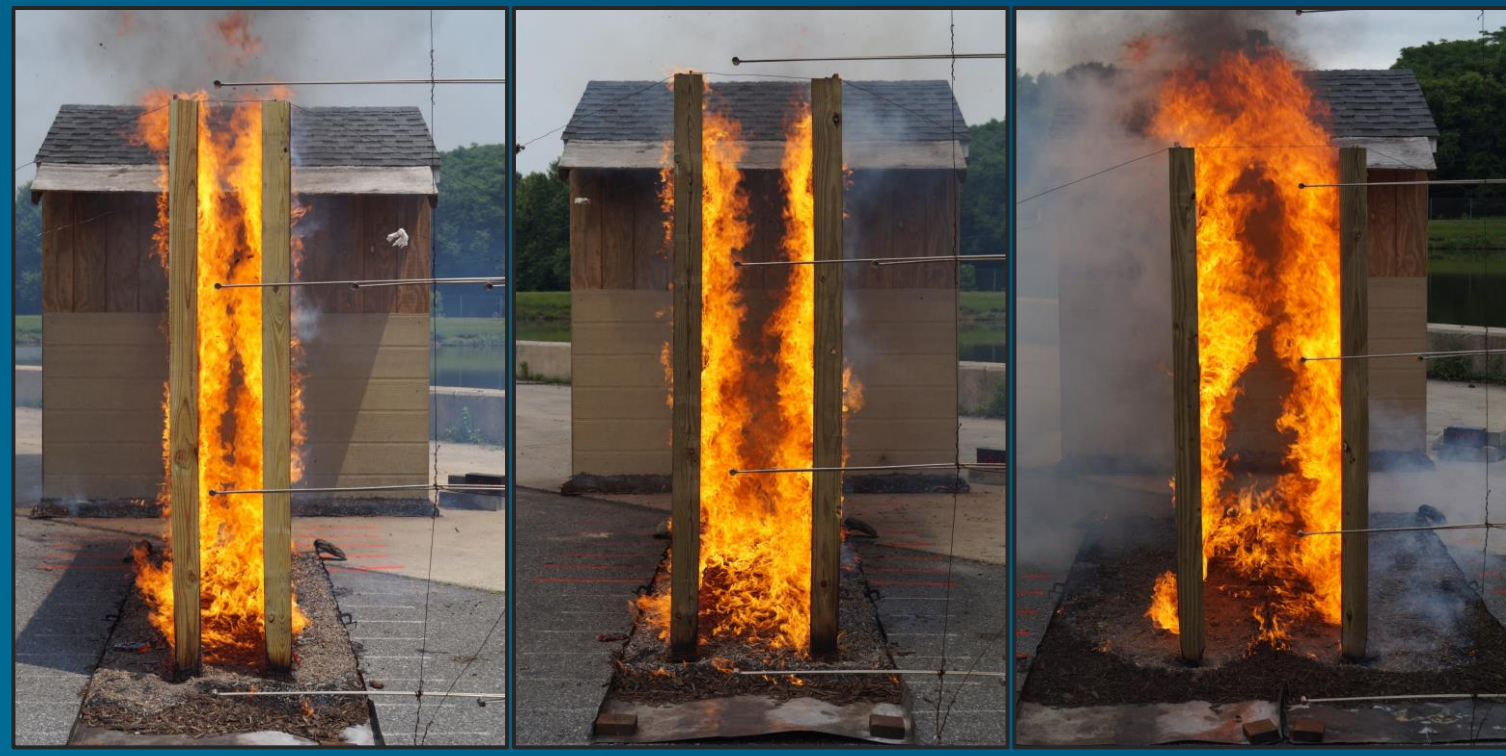
Parallel Fences + Mulch

Low wind (13 mph)

- Fast Horizontal Spread
  - 5-14 minute test duration
  - Non-linear growth
  - Flames above fence
- Fast spotting to shed

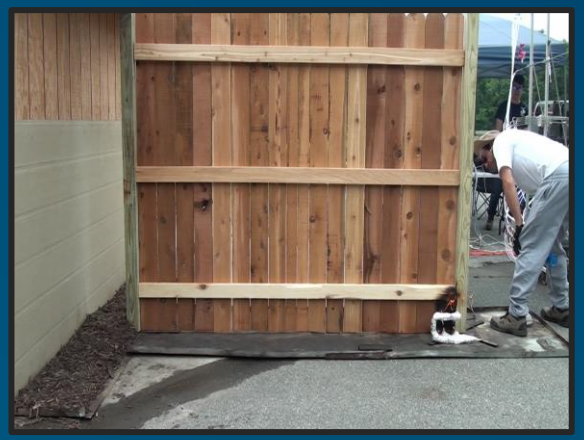
Parallel Fences + Mulch

- Vertical Spread
- Entire Fence Consumed
  - Increased burned area
  - Firebrands
- Why?
  - Radiation
  - Convection



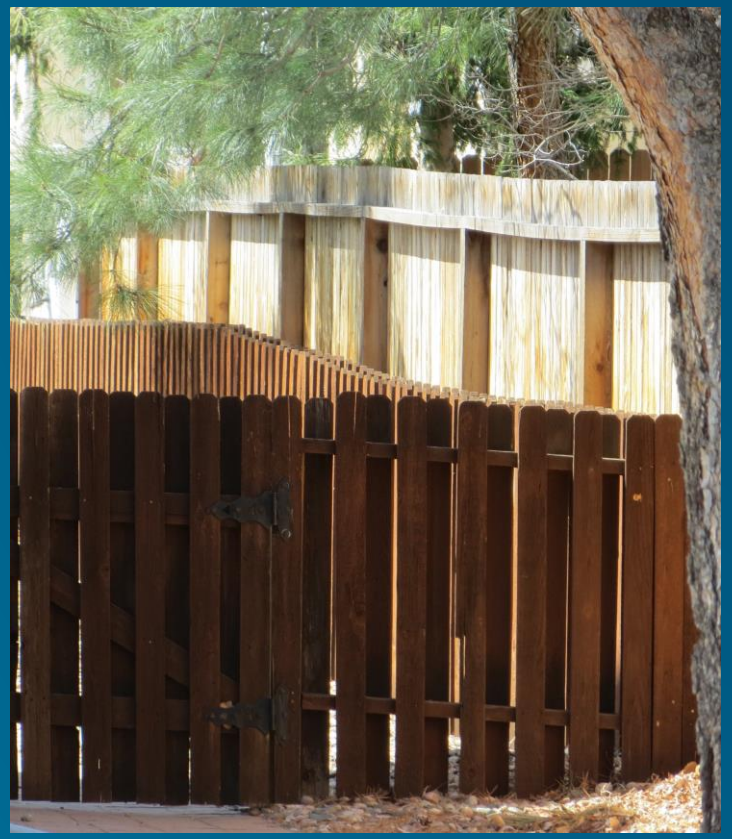
Why Would Parallel Fences Be Constructed?

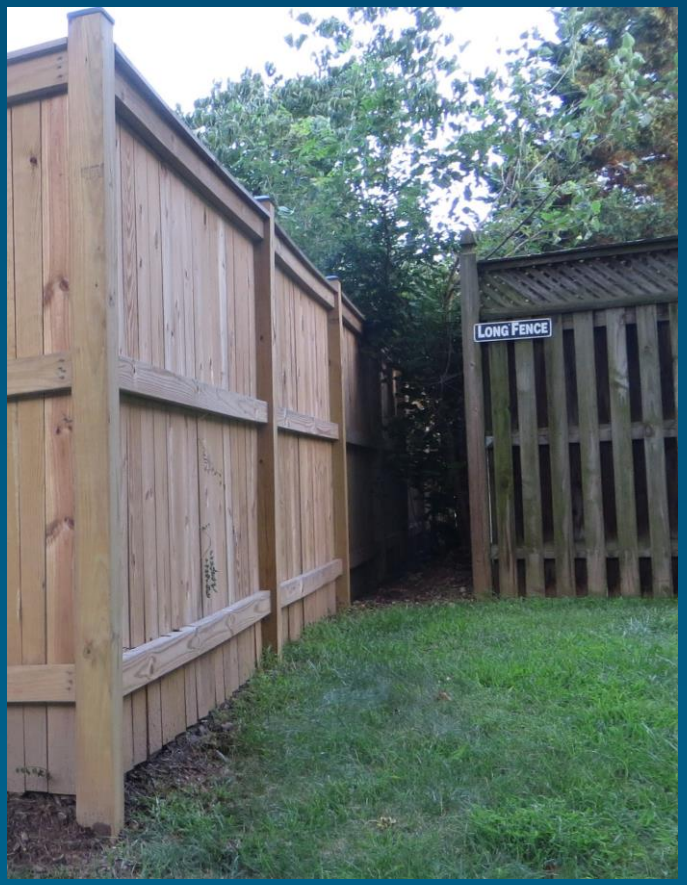
- "Good" and "Bad" sides



Why Would Parallel Fences Be Constructed?

- "Good" and "Bad" sides
- Surrounded by neighbors with various fencing choices
- Preference / Need





Limits of Parallel Fence Fire Behavior

- How far apart to separate fire behavior into two single fences?
- Guidance
  - Homeowners
  - Construction / Installation
  - Building codes

Increasing the Spacing

8 in

12 in

18 in

24 in

Finally …

36 in

Safe? Recommend?

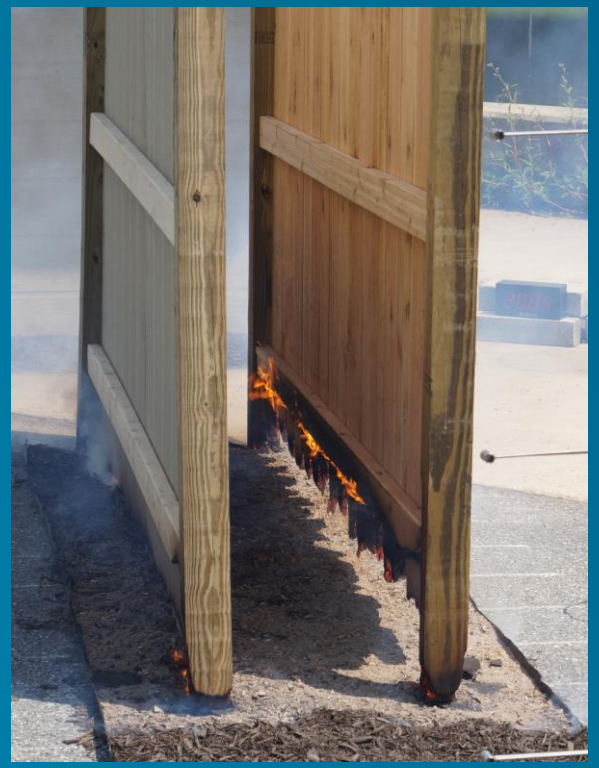
Extended Parallel Fence Test

Experiments: Parallel Fences

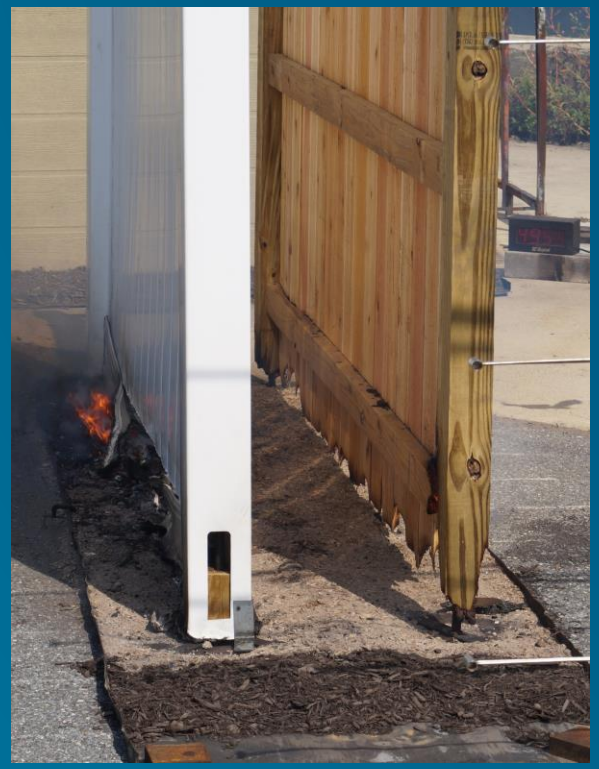
What about fences built next to a wall or other fence types?

Mixed Parallel Fences

- Question: Is there severe fire behavior for a privacy fence near a wall or fence of a different design or material?



Cement Board



Vinyl Fence

Pine Lattice Fence

plus Western Redcedar Privacy Fence at 18 in Spacing

Experiments: Long-Range Firebrands

Experiments: Long-Range Firebrands

- Take away the structure
- Ignition of mulch bed up to 156 ft from source (mulch bed, double lattice fence, woodpile) occurred within 3 min of high wind conditions

Key Findings

Key Findings - General

- Combinations of combustibles increase the hazard disproportionately.

- Fences may impact egress.
- Fire spread rates vary with fence material and design, wind speed, and fuel configuration, including the presence or absence of mulch.
- Spot fires due to firebrands may ignite within a few minutes, even over a distance of 156 ft or more from the burning item, and may continue to ignite long after the initial flaming combustion has subsided.

Key Findings – Very High Hazard

Parallel Fences

Some Wood-Plastic Composite Fences

Good Neighbor Fences

Rubber Mulch

Key Findings – High Hazard

Combustible Fences Plus Mulch

Some Wood-Plastic Composite Fences

Wood-Based Mulch

Pine Straw Mulch

Key Findings – Medium Hazard

Most Fences Absent Fine Combustibles

Vinyl Fences

Artificial Turf

Key Findings – Low Hazard

- Even noncombustible walls (such as stone, brick, or steel) can accumulate leaves, needles, and other debris on which fires can ignite and spread
- Maintenance is important.

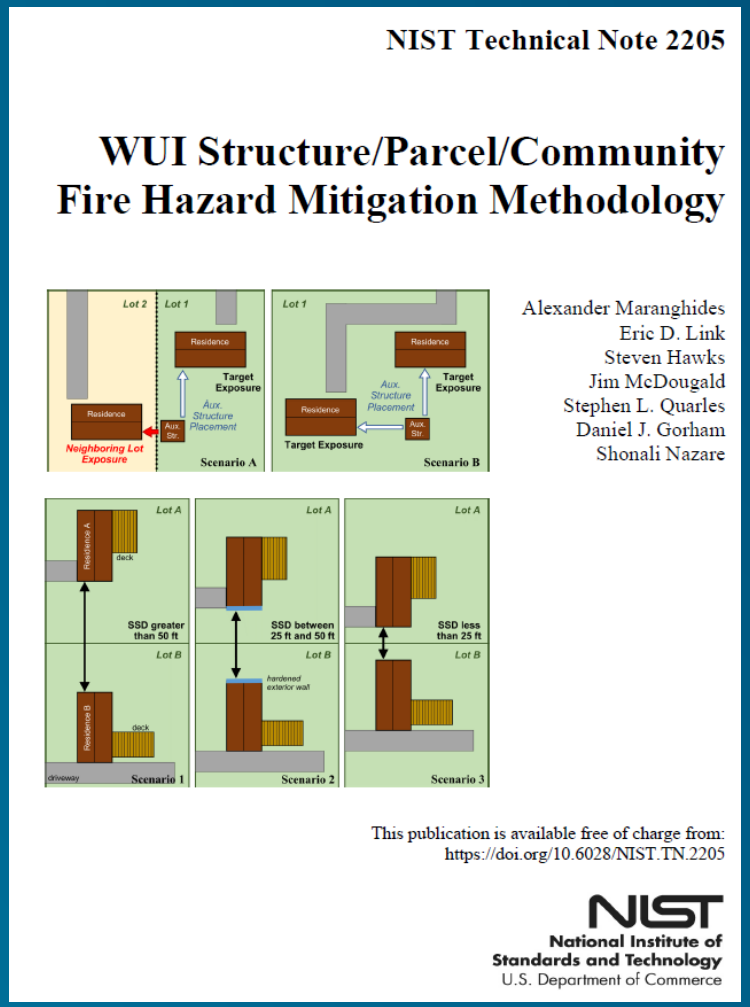
Recommendations

Primary Recommendations

- Avoid parallel fences.
- Avoid combustible fences where they can impact egress.
- Avoid proximity to other combustible fuels.
- Avoid proximity of combustible fences to residence, including neighboring residence.
- Replace combustible landscape feature with noncombustible or low fire hazard features when possible.
- Keep fence and yard clear of debris.
- Harden structures against firebrands.

REDUCE – RELOCATE – REMOVE – HARDEN

Fire Hazard Mitigation Methodology



NIST Technical Note 2205

WUI Structure/Parcel/Community Fire Hazard Mitigation Methodology

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REDUCE – RELOCATE – REMOVE – HARDEN

Recommendations for Future Work

- Study the effects on fire behavior of closely spaced parallel wall surfaces in communities.
- Continue to study the fire behavior of landscape features and potential mitigation methods.
- Improve data collection methods.
- Use fire modeling to better understand the physics behind the fire behavior.
- Develop fire test(s) for evaluating fences and fence materials that represent the actual fire hazard.

Thank you

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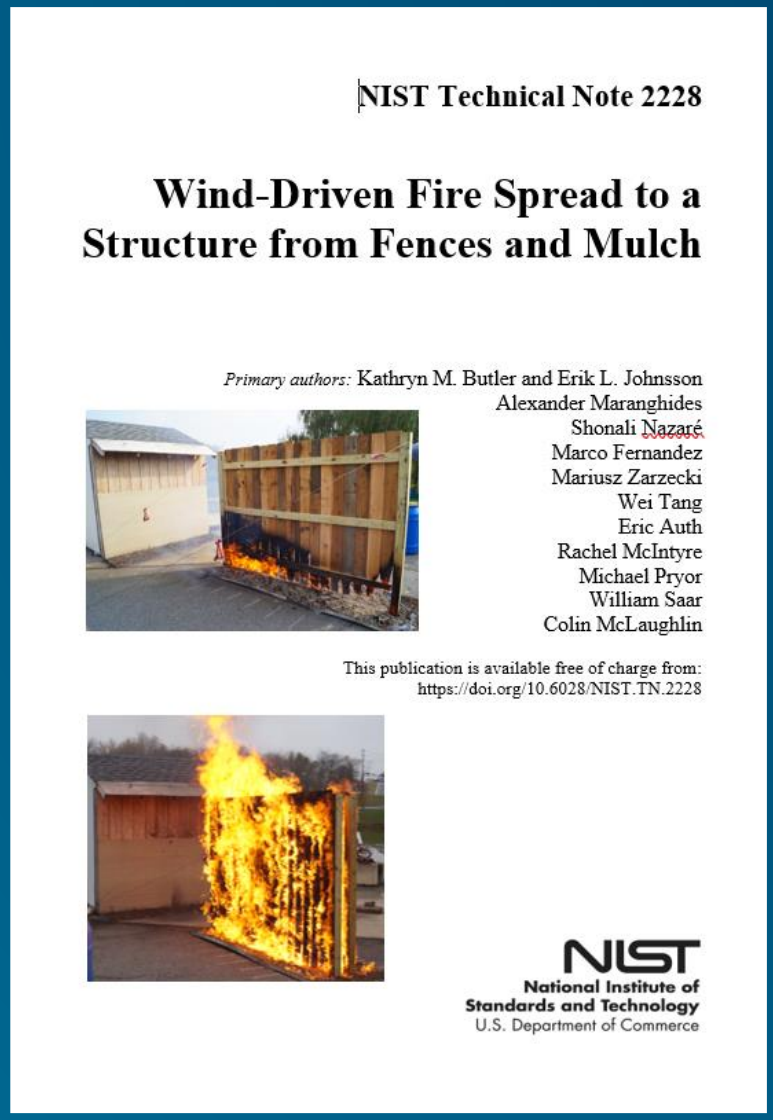

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Wind-Driven Fire Spread to a Structure from Fences and Mulch

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