Wind-Enabled Ember Dousing

A comparison of wildland fire protection strategies

Prepared for the Ramona Fire Recovery Center
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This presentation:

- Introduction to the firebrand threat
- Description of the WEEDS water spray system
- Comparison of water spray and other techniques

The Way Things Were: Reliance on defensible space

- "Clear around your home and stay there, and we'll send somebody out to protect you." – *Ramona fire official, 2002*
- "Preferred insurers" require 250' to 500' distance from fuels. [Insurance Journal, 2004]

Structure ignition by firebrands*

Firebrands are the leading cause of structure loss

- G.C. Ramsay, 1987 – study of 1148 structures (Australia)
- Ethan Foote, Paint Fire analysis, 1993 (Defensible space!)
- Chen & McAneney (Australia), 2004 – 50% structure ignition at 45 m or more (satellite analysis)
- Jack Cohen (USFS) analyses of structure ignition potential
- Plus others…

As determined by:

- Structures too far from fire front
- Observed ignition points (roof, attic, decks, fences)
- Civilian protection highly effective
- Observed density of brands
- Forensic evidence

*a.k.a “Brands”, “Embers”

Idea:

Separate the problem of radiant heat & flame protection
(answer: distance from fuel)

from the problem of firebrand protection…

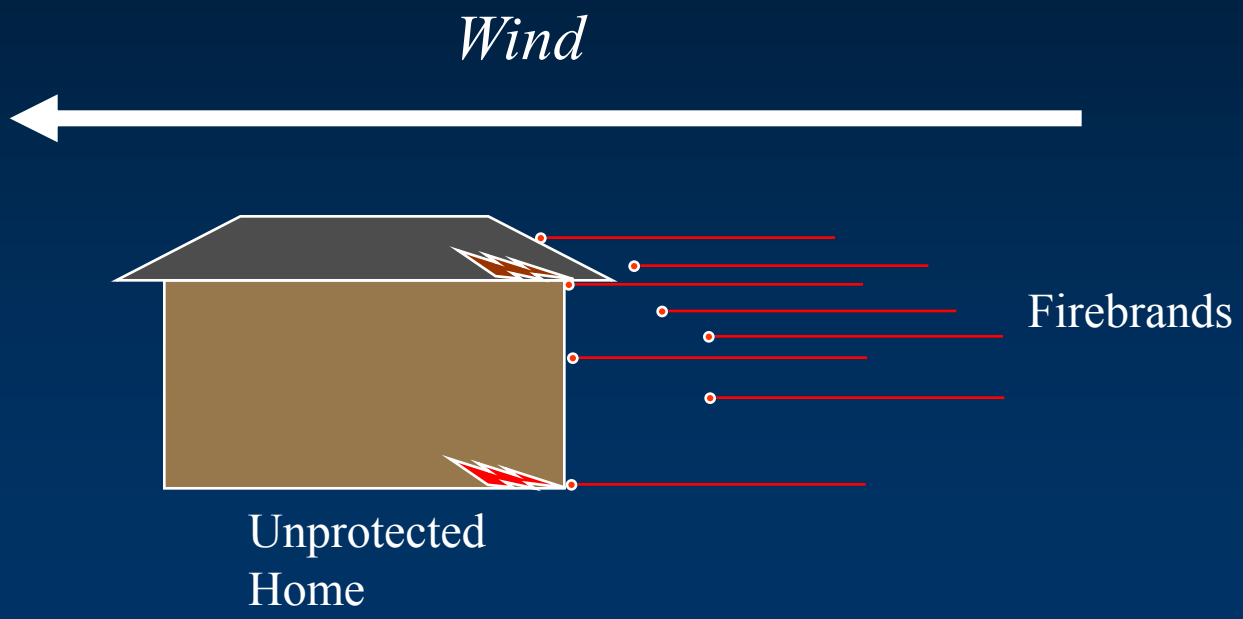
The Need for WEEDS

- The majority of wildland fire structure losses occur during *HIGH WIND CONDITIONS.*
- Structures with *defensible space* are still subject to ignition from *FIREBRANDS*, which can travel up to ½ mile from the fire front.
- Firebrands can be extinguished by small amounts of water, or on wet surfaces.
- Most exterior sprinkler systems are NOT designed for high winds.

WEEDS Principles

- *SPRAY INTO THE WIND*
  Use the wind to blow spray onto the structure. *Maximizes windward protection.*
- *LOW FLOW RATE*
  <30 g.p.m. provides >3 hours protection with a 5000 gallon supply.
- *SUPPLEMENT DEFENSIBLE SPACE*
  100’ clearance to protect from radiant heat.

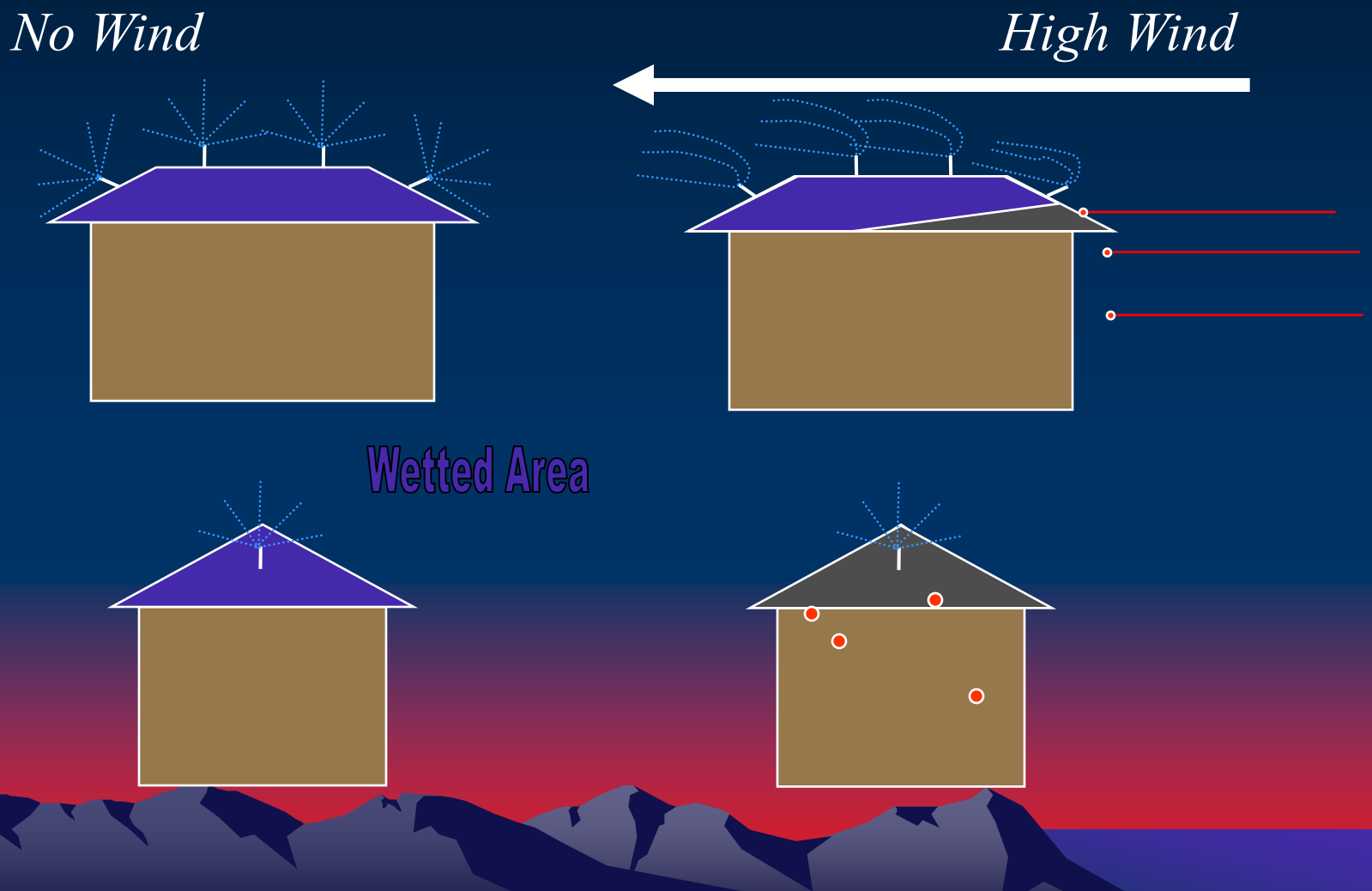
Embers and the Home



Firebrands can:

- Catch under open eaves
- Lodge under loose or curved shingles
- Accumulate at the base of the structure
- Enter attic vents
- Enter window / door seams
- Catch in “nooks & crannies”
- Ignite materials near the structure

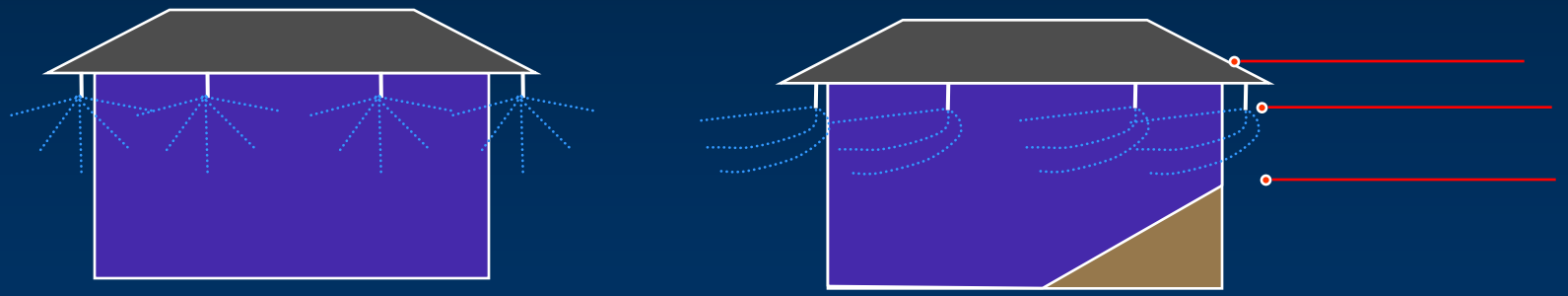
Conventional Sprinkler: On the roof



Conventional Sprinkler: Under Eaves

No Wind

High Wind

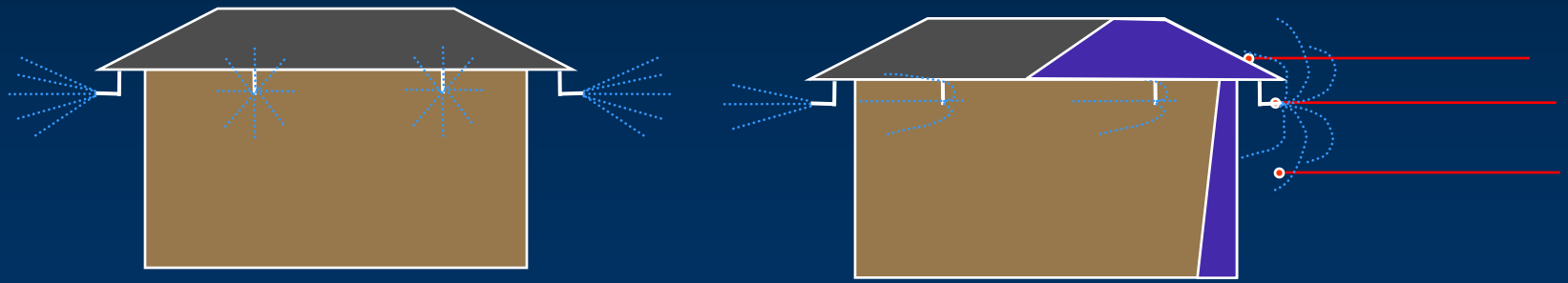


Wetted Area

WEEDS:
Wind-Enabled Ember Dousing System

No Wind

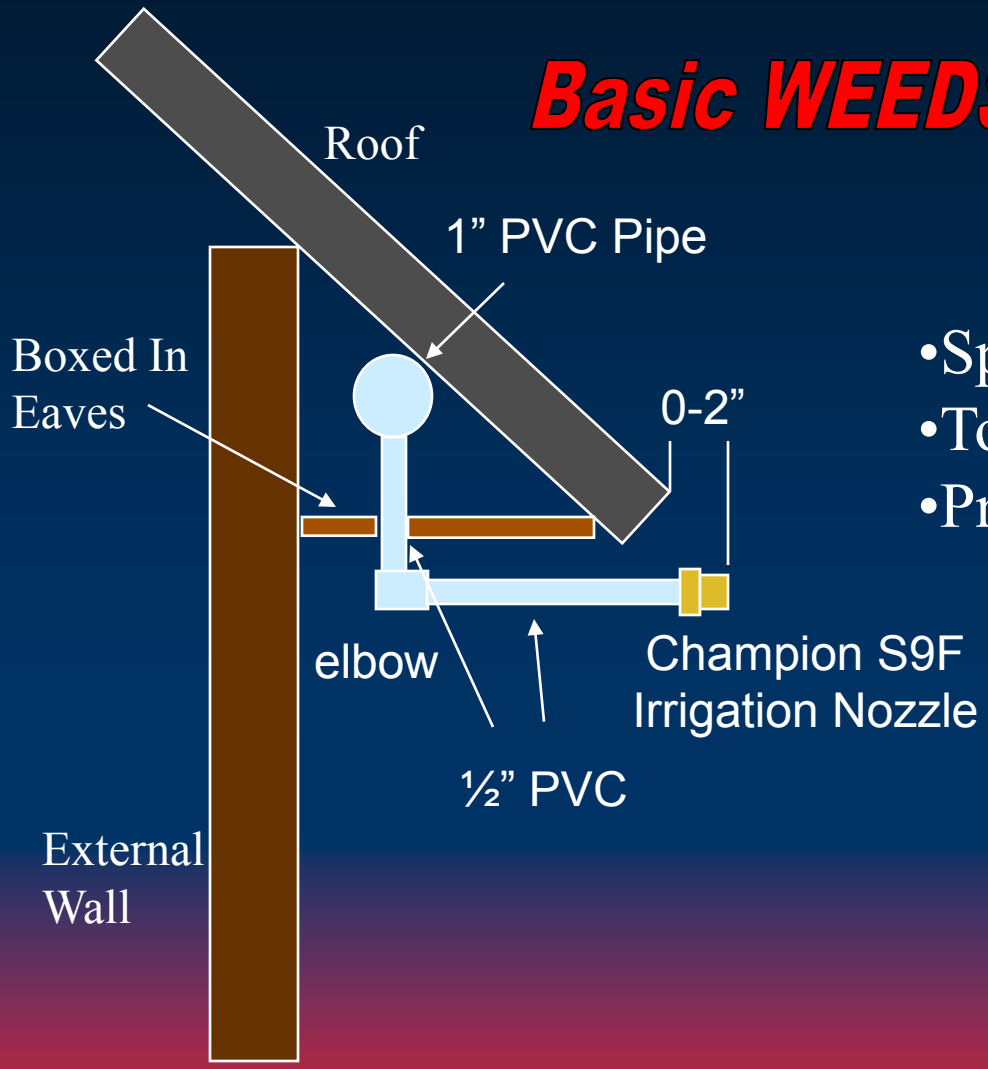
High Wind



Wetted Area

Maximizes Windward Protection

Basic WEEDS Design



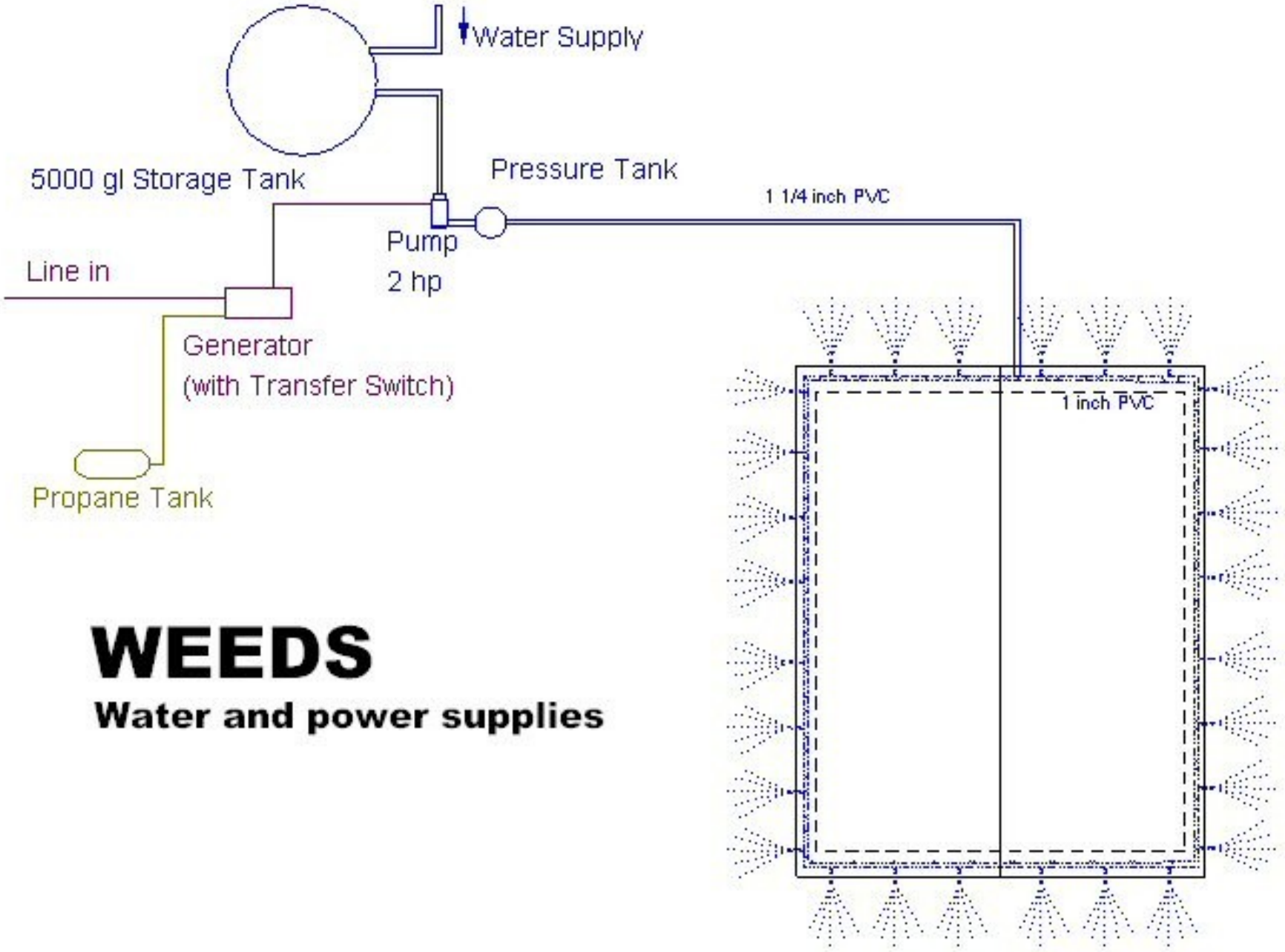
- Spacing of Nozzles: 8 feet
- Total Nozzles: 32
- Pressure at pump: 63 psi

Wind-Enabled Ember Dousing (WEEDS)

CONCEPT: ACHIEVE WIND-RESILIENT BRAND PROTECTION BY DIRECTING COARSE WATER SPRAY OUTWARD FROM THE STRUCTURE

- The wind blows it back onto the structure
- Spray accumulates where embers do (shown by computer simulation
- Low spray densities needed to protect from brands (as opposed to radiant heat)

Published in the international Fire Safety Journal, September 2006



WEEDS

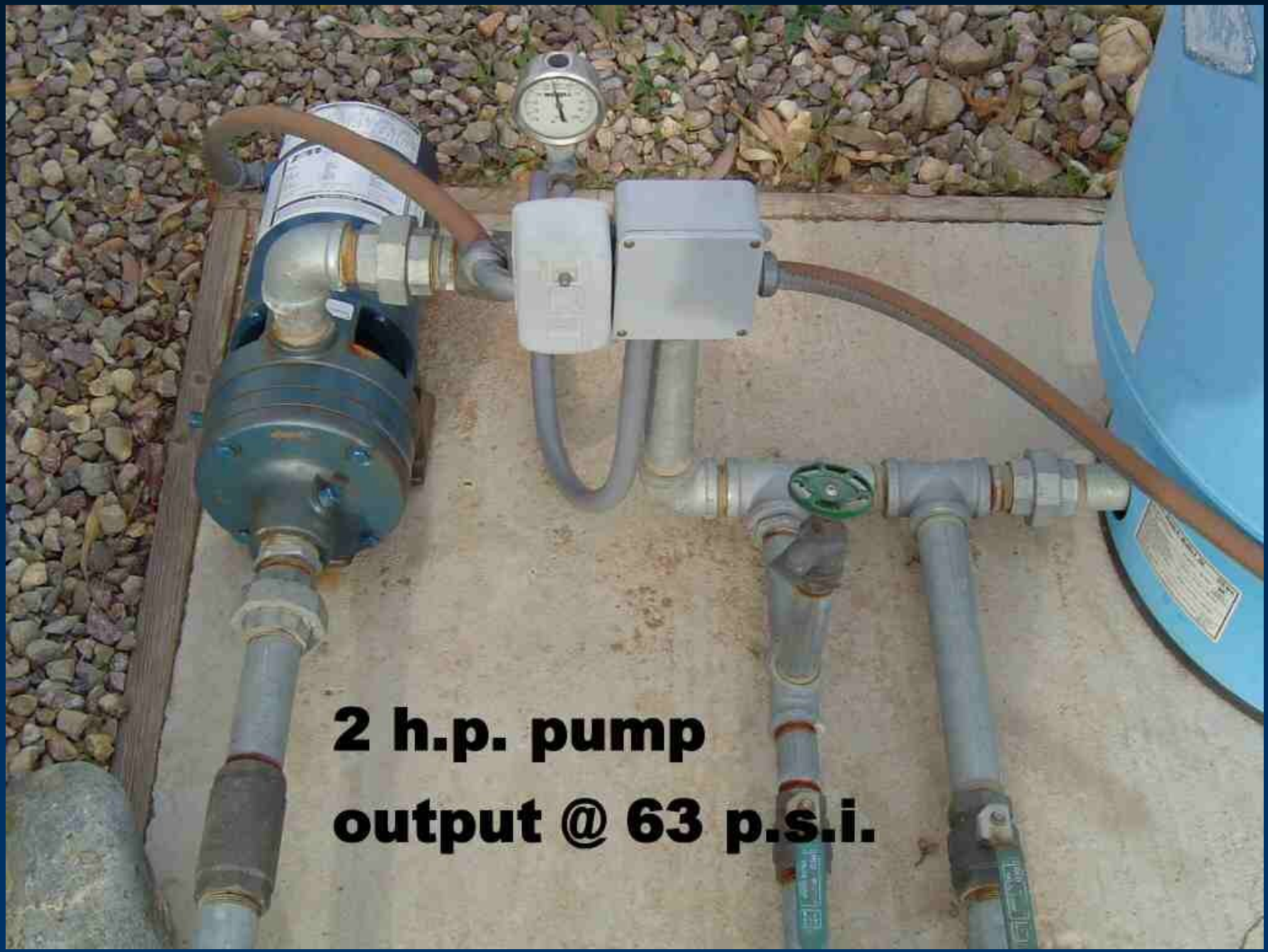
Water and power supplies

WEEDS design features

- Low flow rate (~120 l/min)
- Agricultural spray nozzles
- 5000 US gl water tank (plus municipal supply)
- 12 kW generator (propane)
- 1.5 kW pump
- 3-4+ hour protection window
- *Potential improvements: gravity feed, 10k gal tank, automated or remote triggering*


12 kw generator
propane-fueled


5000 gl. water tank


2 h.p. pump
output @ 63 p.s.i.


Pressure tank


Main valve and
drain valve


North/South branch
valves

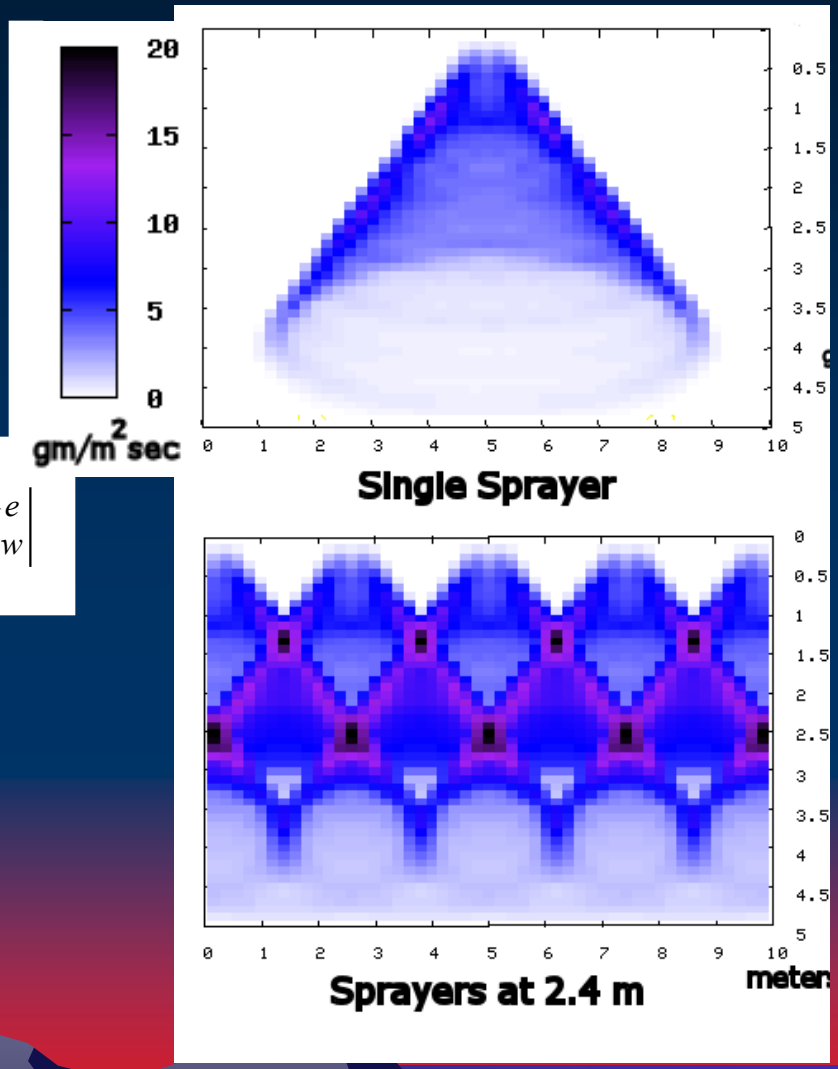

Soffit insertion point

Computer modeling

- Crib experiments suggest 1.5 - 4.0 gm/m^{2}sec is sufficient to extinguish cribs (reviews: Novozhilov et al., Grant et al.)
- Simulation of droplet in wind

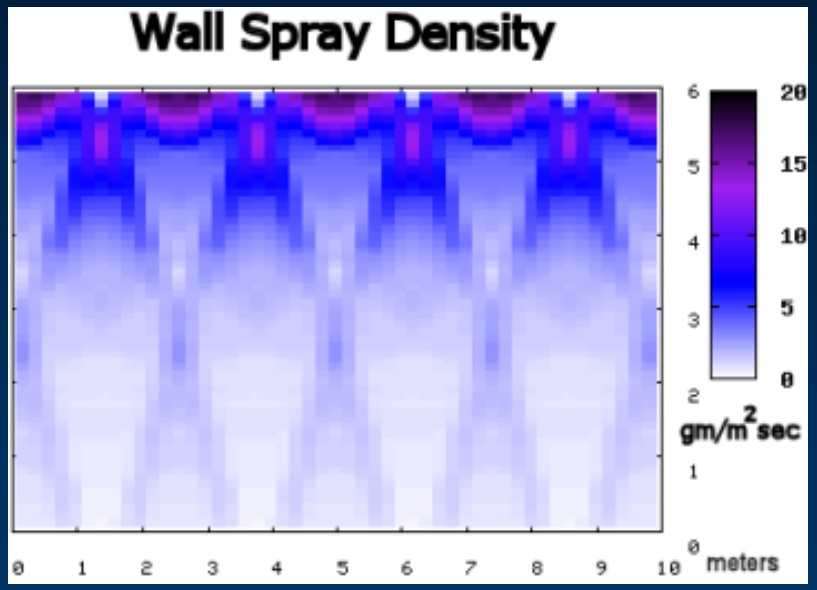
$$\frac{\partial}{\partial} \left(n_d \vec{u}_d \right) = n_d \vec{g} - \rho_d A_d \left(\vec{u}_d - \vec{u}_w \right) \left| \vec{u}_d - \vec{u}_w \right|$$

- Used similar nozzle for droplet size distribution
- Achieves extinguishment zone around the structure at nominal design



Wind resilience of spray

- Results conservative – don't take airflow into account
- Overlap of spray patterns to 50 km/hr
- 40% of spray onto roof / eaves at high wind speed



Wind speed = 20 km/hr

Testing of system

October 26, 2003

- Cedar Fire
- Nominal operation
- Apparent success
- Structures lost on all adjacent properties
- 60-70% loss rate / no professional fire protection
- Forensic evidence of brands on property

Not proof, but a case study (Fire Safety Journal, Sept. 06)

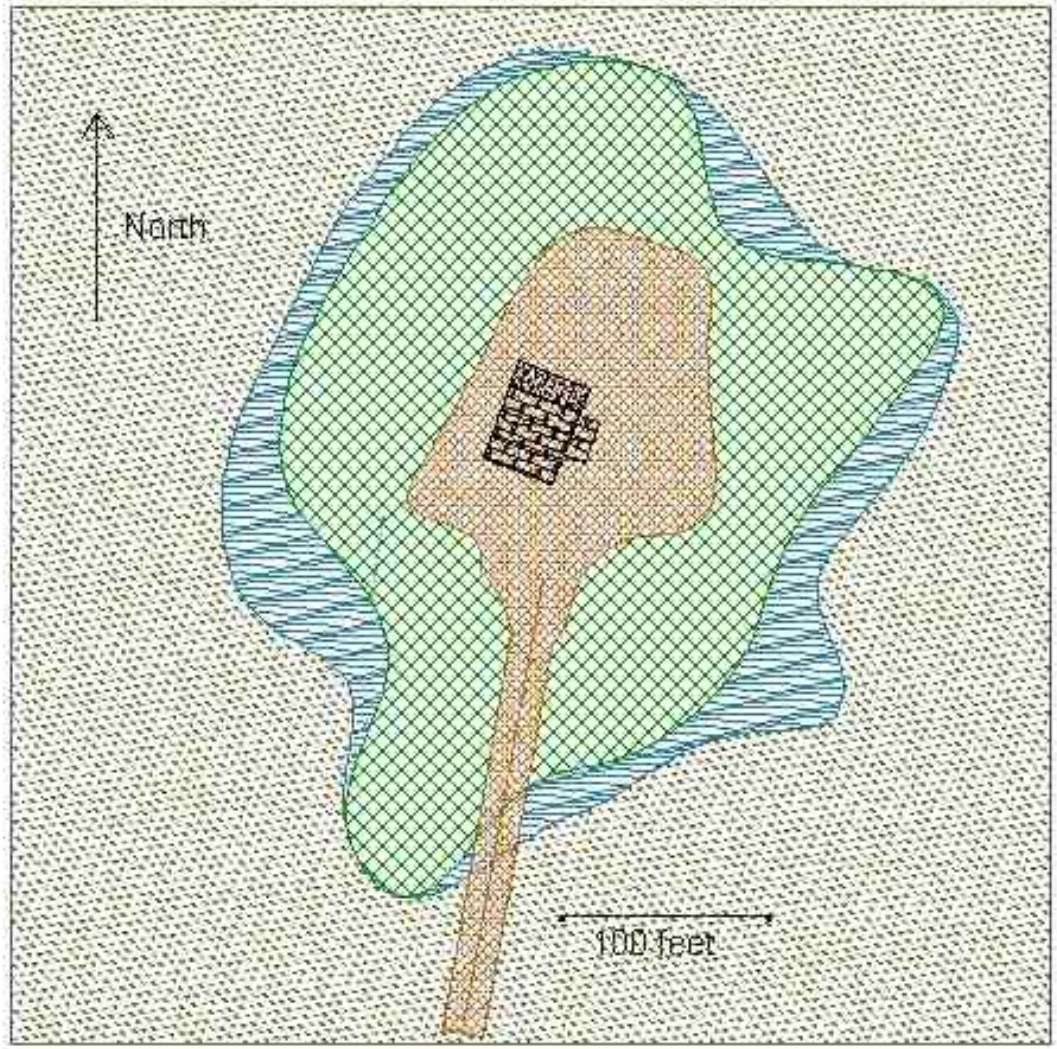
Case Study: Cedar fire - Ramona, CA

- Southern Mussey Grade Neighborhood
  - 106 dwellings destroyed (~2/3 of all)
  - Many had defensible space
  - No professional fire response

Risk & Mitigation

- Fire risks
  - Wood siding, frame, trim
  - Open attic vents
  - Sited on ridge (chimney)
  - Mature (30 yrs.) chaparral
  - Seven year drought
- Mitigating steps
  - 50’ set-back
  - 100’ clearing
  - Boxed eaves
  - Door on one attic vent
  - Class A asphalt shingle roof
  - WEEDS

Pre-Existing Vegetation



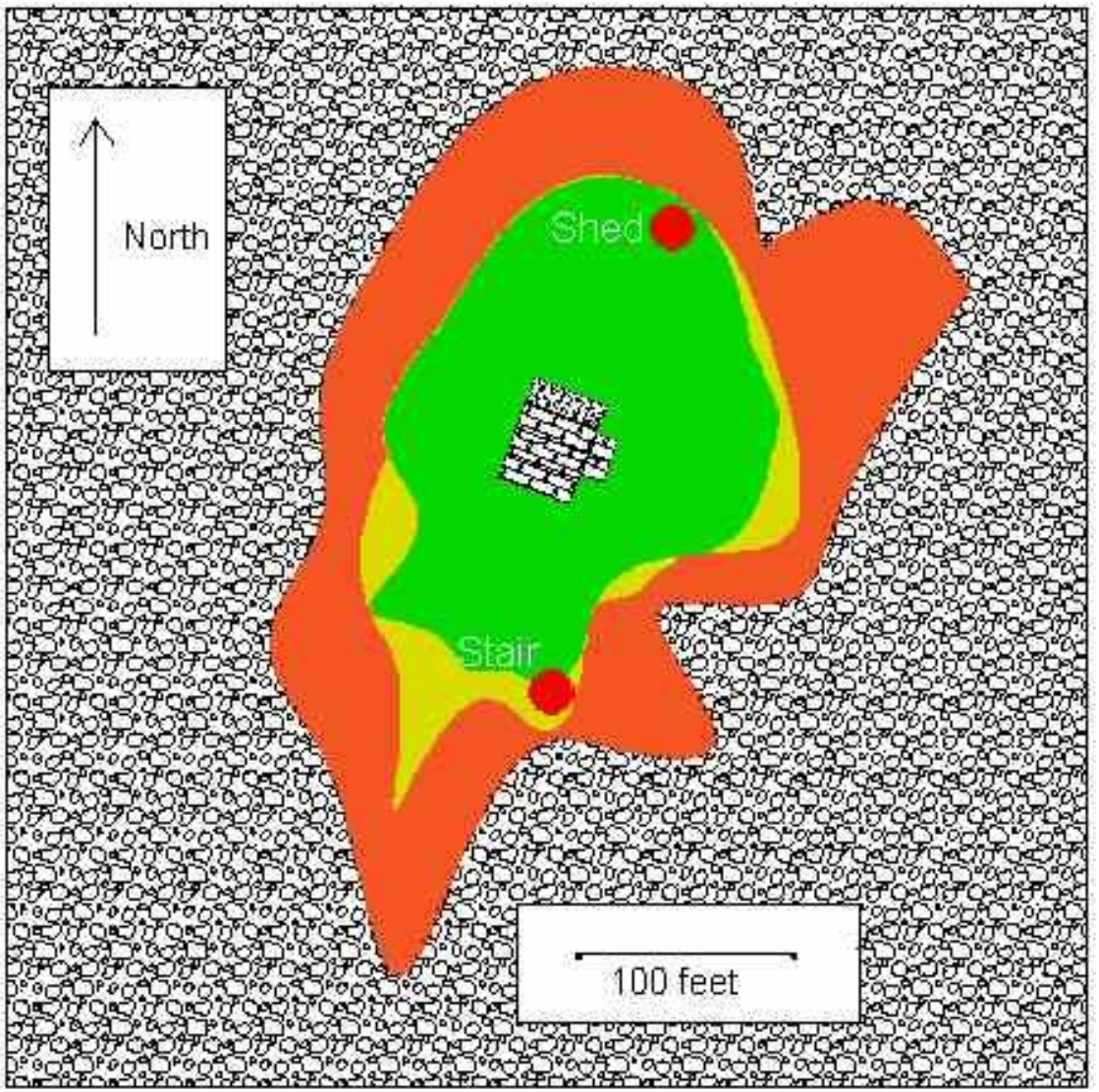
Chaparral
30 year, mixed

Chaparral
thinned, chamise
removed

Plantings
Non-natives plus
sparse native veg.

Cleared pad

Burn Map



No burn damage

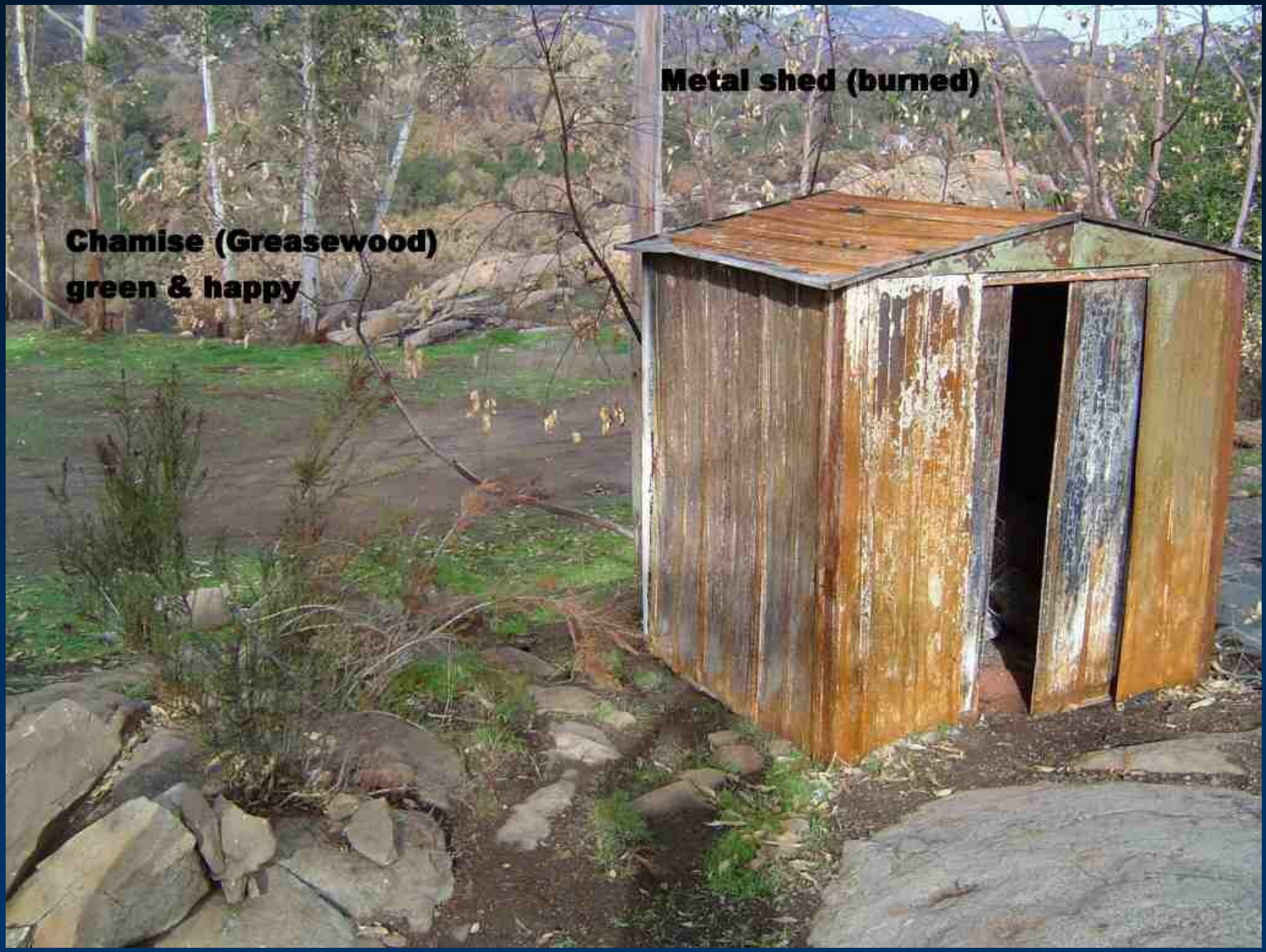
Ember spotting

Light burn
Scorching

Fully burned

Ember Damage

- Metal shed – burned from the inside. Nearby plants green.
- Stair – railroad-tie. Some steps burned. No damage evident on unburned steps.
- Burn marks on unwilted leaves


Metal shed (burned)
Chamise (Greasewood)
green & happy


Ember damage
to wooden stair


Ember marks on lime leaves

WEEDS Publications & Presentations

- Wildfire 2004 poster session, Reno NV
- San Diego Reader, May 2004
- Wildfire Magazine, 2005
- Home & fire Magazine, 2005
- Fire Safety Journal (international refereed publication), 2006
- Third International Fire Ecology and Management Congress, San Diego, CA, 2006
- Fire & Materials 2007, San Francisco, CA

Approaches to Ember Protection:

- Ignition-Resistant Construction
  - New County & State construction codes address ember entry
  - As good as weakest point (vents & screens)
- Water Spray
  - Can cover large area (if wind-designed)
  - Needs reliable supply, during and after fire
- Gel
  - Good for heat load
  - Doesn’t need much water
  - Manual application
  - Harder to fill nooks & crannies

How well do they work?

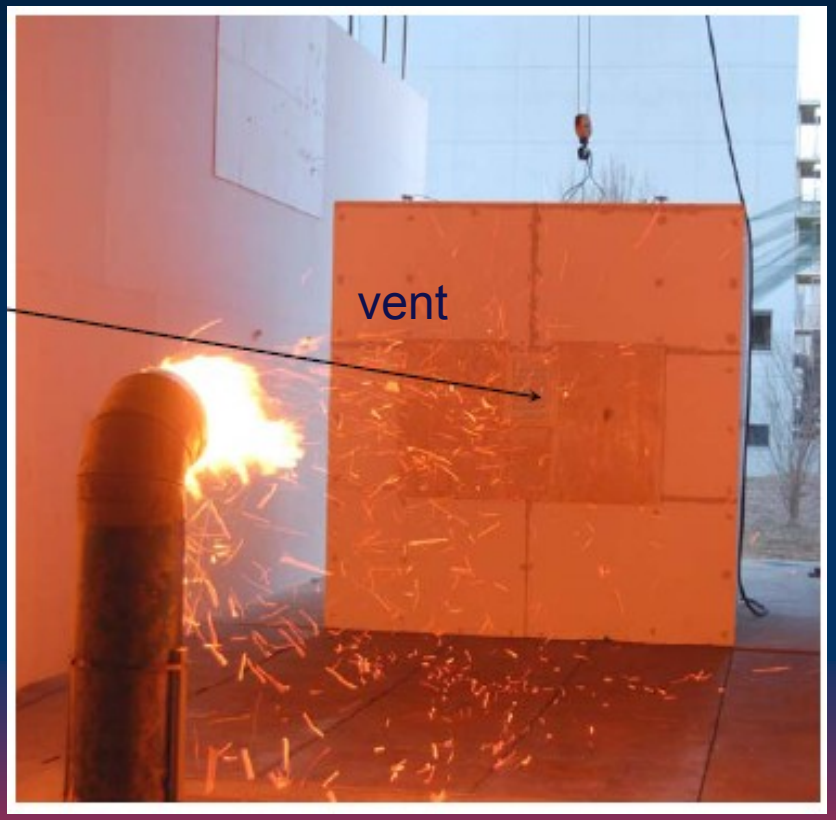
- Controlled scientific data collection sorely lacking in fire-world
- Ignition-resistant construction – vent vulnerability tests
- Gel – Anecdotal & one Canadian trial
- Water spray – Canadian trial & Paint Fire data

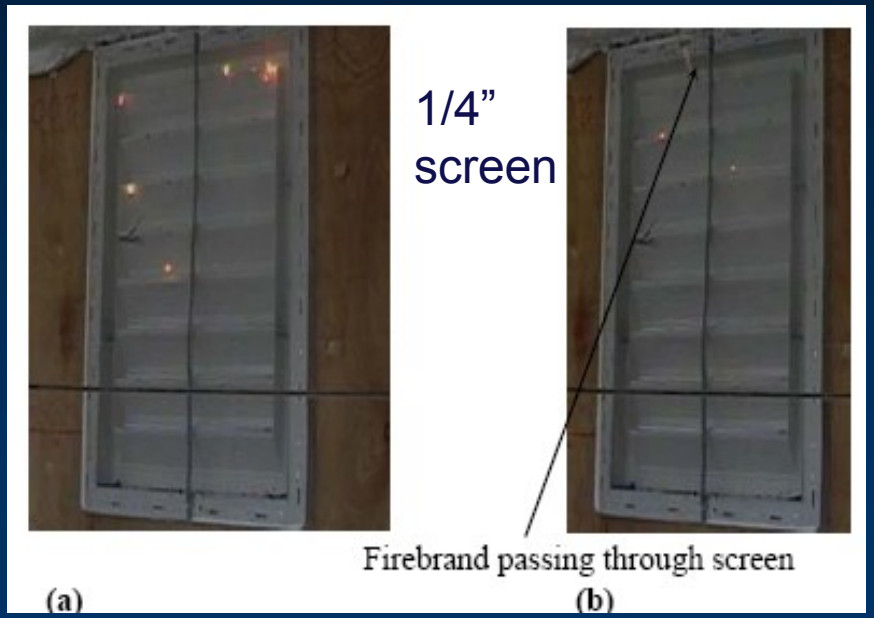
Our construction codes: How fire-safe?

NIST tests (Sam Manzello + colleagues)

Tested ability of ¼” screen to prevent ember “burn-through”

NIST + BRI (Japan): The “Firebrand Generator” (2007)





“Burn-through” embers shown to ignite paper

Gel Anecdote

- USA Today – 25/27 homes sprayed saved (not a controlled study!)

AP Photo/Joe Kafka) :: In this photo provided by Steve Blote, Gorden Sabo applies fireproof gel to a home on Aug. 12, 2007, near Sheridan, Wyo., during the Little Goose Fire that swept across 7.5 square miles of forest. Three homes were destroyed and about 100 others were threatened. The home sprayed by Sabo was saved, although the area around it was blackened by the flames. Sabo gelled 20 homes, including three that were in the direct path of the fire and could not be saved.

FERIC study

(The Forest Engineering Research Institute of Canada)

Limited test –

Step 1) Build two cabins

Step 2) Equip one with sprinklers and cover the other in gel

FERIC study

Step 3) Burn down the forest

FERIC Result:

Water spray

Gel

- Water spray 1, Gel 0
- Lesson – make sure to cover all “nooks & crannies” if using gel
- Cover surrounding vegetation too

Re-evaluation of Paint Fire data

Ethan Foote thesis results on water spray

	Destroyed	Survived	Total	Probability
Structures without external sprinklers	32	148	180	
Sprinklers before fire	4	17	21	0.89
Sprinklers during fire	1	37	38	0.01
Sprinklers after fire	1	33	34	0.01

Multivariate analysis found significance at >90% confidence level (but not 95%)

What this means…

- Statistics aren't very strong (not enough data), but that which we have suggests that water spray may increase survival odds by (very approximately) 7X.

- Re-analysis presented at the Fire & Materials 2007 conference by myself & Oren Patashnik

Water Spray “Gotchya’s”

- DURATION – Need to apply DURING and AFTER fire front – several hours best. 10k tank (6-8 hrs) better than 5k tank (3-4 hours).
- ACTIVATION – Can’t activate too far in advance. But you need to evacuate well in advance to be safe!
- AUTOMATION – DO NOT USE HEAT ACTIVATION (used for internal sprinklers)

Mt. Stromlo, Australia 2003

Lesson: If sprinklers come on due to heat, windows will be too hot, and may shatter from the thermal shock.

Summary

- Low volume water spray systems that compensate for wind can be effective.
- Structures can withstand extreme wildfire conditions without professional intervention
- Approach radiant heat and firebrands as separate problems
- Design for WIND!
- Don’t depend on external power or water sources
- Don’t use “interior sprinkler” design