National Institute of Standards and Technology

Wildland-Urban Interface (WUI) Fires – Experiments and Modeling

http://fire.nist.gov/wui

Building and Fire Research Laboratory

June, 2008

Wildland-Urban Interface (WUI)

- The WUI is where structures and wildland vegetation coexist
- 39% of homes (44 million) in the lower US states are in the WUI
- 42% of homes (5 million) in California are in the WUI; 3.2 million significant risk
- WUI fires can be a significant community threat depending on:
  - -climate, weather, and topography
  - -homeowner landscaping
  - -home design, construction & materials

Problems/Challenges

- The number of structures in WUI is increasing rapidly
- Scientific basis needed for building codes and standards to guide construction of new structures in areas known to be prone to WUI fires
- No physics-based model with predictive capability for either wildland or WUI fires exists, despite revolutionary advances in computer performance
- A multi-person, multi-year research program is needed to develop, verify/validate a predictive, physics-based model and provide scientific basis for WUI building codes and standards

Volker C. Radeloff and Jason F. McKeefry, *The 2000 Wildland-Urban Interface in the U.S.* (Madison, Wisconsin) http://silvis.forest.wisc.edu/projects/WUI_Main.asp

Objectives

- Develop tools for reducing community losses in the wildland-urban interface
- Tools will assist communities in their fire risk assessment and choice of economically balanced mitigation strategies that limit ignition of residences and improve firefighter and community safety

Products/Tools

- Fire behavior/smoke movement predictions
- Provide scientific basis for:
  - risk assessment and mitigation
  - building standards and codes
- Economic impact of mitigation

NIST Effort - Four Projects:

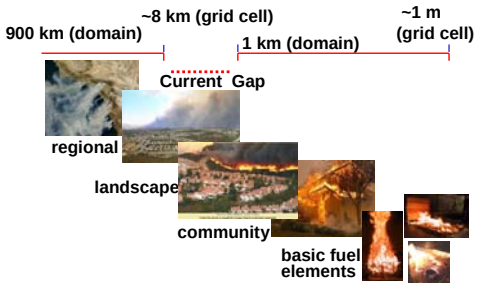
- Develop Outdoor Scale Fire Models
- Experimental Studies of Structural Ignition
- Post-Fire Event Analysis
- Measuring Fire Resilience of WUI Economies

Outdoor Scale Fire Models

POC (Modeling): William Mell +1-301-975-4797

Challenge: Wide range of scales

NOAA's Fire Weather Model **NIST's Community Scale Fire Behavior Model (WFDS)**



Approach: Two Levels of WUI Modeling

LEVEL 1 – Community Scale – WFDS – validation underway – strategic use

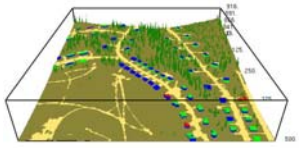
- **100 s of meters domain size**
- **More detailed physics-based fire behavior**

LEVEL 2 – Landscape Scale – started in 2007 – operational/tactical use

- **1000s of meters domain size**
- **Relatively more semi-empirical based fire behavior**
- **Fast turn around time on simulations (e.g., aid responders)**
- **Provide input to larger scale atmospheric based models (NOAA)**

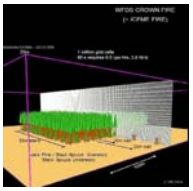
WFDS: Creation of community input data

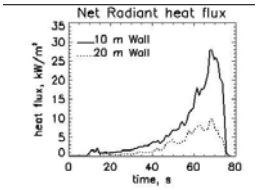
Community features derived from LiDAR and the National Agricultural Imagery Program (NAIP) multispectral data. These give terrain, building footprints and heights; tree locations and attributes; fire barriers (roads, tracks, bare earth)



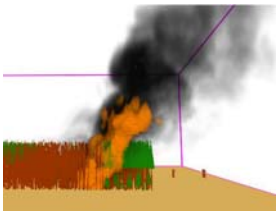
WFDS representation of neighborhood in Worley, Idaho using LiDAR & NAIP with ground truthing. Structure colored according to NFPA fire-risk factors

WFDS: Simulation of International Crown Fire Modeling Experiments





Alexander, 2006



WFDS Result

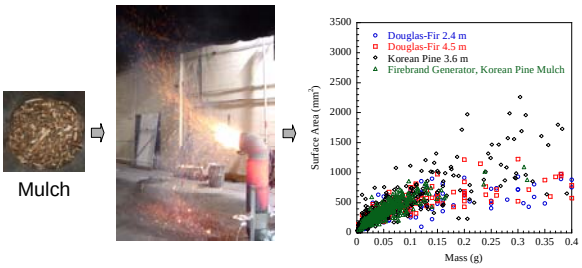
Acknowledgments:
This research was partially funded by the USDA Forest Service.

Experimental Investigation of Structural Ignition in WUI Fires

POC (Structure Ignition): Samuel Manzello +1-301-975-6891

Unique Firebrand Generator Developed

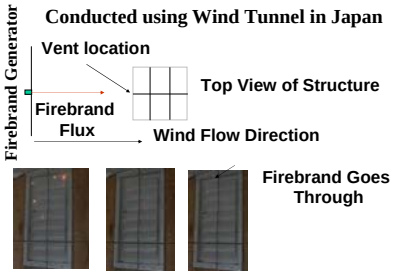
'Engineer' a Firebrand Distribution
Direct Firebrand Flux to Test Ignition of Structures



Firebrand Penetration Through Vents

Gable Vent

Conducted using Wind Tunnel in Japan



Screen Behind Vent
Three sizes tested 6 mm , 3 mm , and 1.5 mm

Screens unable to block firebrand penetration
Ignition observed inside structure

Roofing Tests

Gutter filled with needles/leaves

Rapid Response Packages

- **Develop rapid response instrumentation packages**
- **Document structural ignition mechanisms during actual WUI fires**
- **Measure progression and characteristics of fire for model validation**
- **First generation packages to be tested in prescribed burns**

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Post-Fire Event Analysis

POC (Post-Fire): Alex Maranghides +1-301-975-4886

Analyze community impacted by 2007 Southern California Fire

Objective: determine fire behavior at the WUI, including ignition particulars for the destroyed structures

The Trails **at Ranch Bernardo, CA**

74 out of 250 structures were destroyed

Roof Type Assessment

Objective: Identify roof type failures and provide guidance to laboratory firebrand ignition experiments using Firebrand Generator

Bird stops present

Bird stops absent

	Wood	Steel	Spanish tile – no bird stops	Spanish tile – w/ bird stops	Composite	Total
Exposed	12	2	100	53	78	245
Destroyed	12	1	29	8	24	74
Ratio (D/E)	1	0.5	0.3	0.2	0.3	0.3

FIREWISE Methodology Assessment

Objective: Assess effectiveness and implementation of FIREWISE guidance. Specifically identify if destroyed structures were less FIREWISE that unburned structures. Identify if a FIREWISE methodology is implementable in the community of interest.

R=100 ft FIREWISE Implementation evaluation

Economic Analysis

POC (Economics): David Butry +1-301-975-6136

Current Research Projects:

Economics of Investing in Community Fire Resilience

Objective: To develop a community-based decision support tool evaluating the economic impacts fire mitigation strategies, fire protection technologies, and community attributes (e.g., topography, forest fuel levels, demographics) have on the disaster resilience of local communities against wildland fire threats and vulnerabilities

Evaluating the Economics of Interdependent Wildfire Risk in WUI Communities

***Objective*:** To measure the returns on mitigation investment in WUI communities when wildfire risk is related to the actions of neighboring homeowners

Estimating the Efficacy of Fire Prevention Efforts

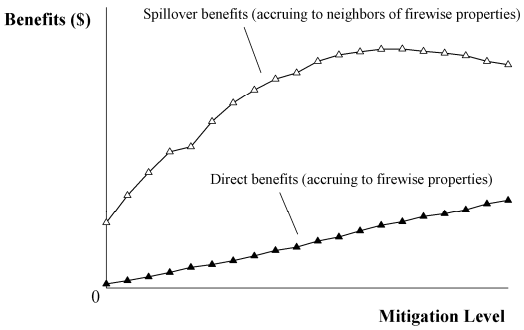
Objective: To estimate the effect coordinated fire prevention and education campaigns have on the incidence of human-caused wildfire ignitions

Spatio-Temporal Modeling of Arson

Objective: To predict the occurrence of wildland and structural arson ignitions using a spatio-temporal model of crime

Recent Results:

Firewise Properties Provide Community Benefits



Findings: Interdependent risk implies that (1) homeowner investment into fire risk reduction activities (i.e., firewise activities) yield positive economic benefits to neighbors through spillover effects; (2) the location of firewise properties within the community matters; and (3) for the same level of expenditure, the concentration of mitigation effort at the interface properties (those bordering the wildland hazard) appear more effective than the treatment of all properties equally.