NIST Special Publication 1213

Summary of Workshop Large Outdoor Fires and the Built Environment

Sponsored by the International Association for Fire Safety Science (IAFSS)

Samuel L. Manzello
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Michael Gollner
Sara McAllister
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Guillermo Rein
Pedro Reszka
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THE INTERNATIONAL ASSOCIATION FOR FIRE SAFETY SCIENCE

National Institute of Standards and Technology
U.S. Department of Commerce

NIST Special Publication 1213

Summary of Workshop Large Outdoor Fires and the Built Environment

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July 2017

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Kent Rochford, Acting NIST Director and Under Secretary of Commerce for Standards and Technology

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Abstract

Large outdoor fires present a risk to the built environment. In this workshop, presentations highlighted large outdoor fires throughout the world, and explored common characteristics between these fires. Specifically, each presentation provided an overview of the large outdoor fire risk to the built environment from each region, and *highlighted critical research* needs for this problem in the context of *fire safety science*. The workshop seeks to develop the foundation for an international research needs roadmap to reduce the risk of large outdoor fires to the built environment. This workshop also provided a forum for *next generation researchers* to contribute to this important topic.

Key words

Large Outdoor Fires; Urban Fires; Wildland-Urban Interface (WUI) Fires

Table of Contents

1. Introduction

1.1. Workshop Objectives

Large outdoor fires present a risk to the built environment. One example often in the international media reports are wildfires that spread into communities, referred to as Wildland-Urban Interface (WUI) fires. WUI fires have destroyed communities throughout the world and are an emerging problem in fire safety science. Another example are large urban fires including those that have occurred after earthquakes.

Historically, fire safety science research has spent a great deal of effort to understand fire dynamics within buildings. Research into large outdoor fires, and how to potentially mitigate the loss of structures in such fires, lags behind other areas of fire safety science research[1]. This is due to the fact that fire spread in large outdoor fires is incredibly complex, involving the interaction of topography, weather, vegetation, and structures. At the same time, common characteristics between fire spread in WUI fires and urban fires have not been fully exploited. Once a wildland fire reaches a community and ignites structures, structure-structure fire spread can occur under similar mechanisms as in urban fire spread.

In this workshop, presentations highlighted large outdoor fires throughout the world, and explored common characteristics between these fires. Specifically, each presentation provided an overview of the large outdoor fire risk to the built environment from each region, and *highlighted critical research* needs for this problem in the context of *fire safety science*. The workshop will seek to develop the foundation for an international research needs roadmap to reduce the risk of large outdoor fires to the built environment. This workshop also provided a forum for *next generation researchers* to contribute to this important topic.

1.2. Program of the Workshop

Welcome and Workshop Objectives (5 min total)
Samuel Manzello (NIST, USA)

Large Outdoor Fires and the Built Environment – European View (30 min total)
Eulàlia Planas (UPC, Spain) /Guillermo Rein (Imperial College London, UK)
15 min oral presentation followed by 15 min open discussion on European View

Large Outdoor Fires and the Built Environment – Asian View (30 min total)
Sayaka Suzuki (NRIFD, Japan)
15 min oral presentation followed by 15 min open discussion on Asian View

Large Outdoor Fires and the Built Environment – North American View (30 min total)
Sara McAllister (USFS, USA)/Michael Gollner (University of Maryland, USA)
15 min oral presentation followed by 15 min open discussion on North American View

Large Outdoor Fires and the Built Environment – South American View (30 min total)
Pedro Reszka (UAI, Chile)
15 min oral presentation followed by 15 min open discussion on South American View

Large Outdoor Fires and the Built Environment – Oceania View (30 min total)
Raphaele Blanchi
15 min oral presentation followed by 15 min open discussion on Oceania View

Open Discussion (30 min total)
Samuel Manzello (moderator)
30 min final open discussion on common aspects between all regions; highlight research needs common to all regions

1.3. List of Registered Participants (Alphabetical Order by Surname)

Arvind Atreya (University of Michigan, USA)
Raphaele Blanchi (CSIRO, Australia)
Eirik Christensen (Imperial College London, UK)
Monica Diab (Dalhouise University, Canada)
Alexander Filkov (University of Melbourne, Australia)
Kevin Frank (BRANZ, New Zealand)
Michael Gollner (University of Maryland, USA)
Daniel Gorham (NFPA, USA)
Rory Hadden (University of Edinburgh, UK)
Peter Hamlington (University of Colorado, USA)
Ahreum Han (UL, USA)
Jan Hora (Technical University of Ostrava, Czech Republic)
Longhua Hu (USTC, China)
Xinyan Huang (University of California-Berkeley, USA)
Erica Kuligowski (NIST, USA)
Aymeric Lamorlette (Aix Marseille University, France)
Chris Lautenberger (REAX Engineering, USA)
Jiao Lei (USTC, China)
Ying Zhen Li (RISE, Sweden)
Justin Leonard (CSIRO, Australia)
Samuel Manzello (NIST, USA)
Sara McAllister (USFS, USA)
Marion Meinert (DBI, Denmark)
Colin Miller (University of Maryland, USA)
Pierrick Mindykowski (RISE, Sweden)
Elsa Pastor (UPC, Spain)
Eulàlia Planas (UPC, Spain)
Guillermo Rein (Imperial College London, UK)
Franz Richter (Imperial College London, UK)
Enrico Ronchi (Lund University, Sweden)
Albert Simeoni (Jensen Hughes, USA)
Junichi Suzuki (NILIM, Japan)
Sayaka Suzuki (NRIFD, Japan)
Jan Christian Thomas (University of Edinburgh, UK)
James Tien (Case Western Reserve University, USA)
Arnaud Trouvé (University of Maryland, USA)
Mario Miguel Valero (UPC, Spain)
Rahul Wadhwani (Victoria University, Australia)

2. Summary and Next Steps

Seven panelists from around the world presented regional overviews of the large outdoor fire problem related to the built environment in their respective regions. The presentations were arranged as: European View, Asian View, North American View, South American View, and Oceania View. A significant discussion outcome of the workshop was the desire of the participants to make this topic a permanent working group under the umbrella of the International Association for Fire Safety Science (IAFSS). So far, this has been done for only one other topic, the Measurement and Computation of Fire Phenomena (MaCFP) working group[2], led by professors Jose Torero (University of Maryland, USA), Arnaud Trouvé (University of Maryland, USA), and Bart Merci (Ghent University, Belgium), supporting modeling, a legacy topic in fire safety science. The process has now begun to define the objectives and goals for the permanent working group focused on Large Outdoor Fires and the Built Environment, and Manzello will appoint additional co-leaders to share the workload.

Due to structure and organization of the workshop, it was apparent that large outdoor fires and built environment encompass far more than only wildfires, and the working group will address problems with key phenomenological shared characteristics relevant to *both* urban fires, and wildland-urban interface (WUI) fires. Overall, the workshop was considered a fruitful endeavor and clearly highlighted that much needs to be done in this research area, as it is far behind the *legacy* topics that have been around in fire safety science for decades. Many *next generation researchers* attended and were encouraged to work in this area, as research impact is possible.

The interested reader will appreciate that a team has been formed to develop a manuscript for *Fire Safety Journal*, the official journal of the IAFSS, to delineate the key findings of the workshop in fine detail, and form the basis for an international research needs roadmap for this topic. One unique aspect of the paper is that it will also include an African view, as this was not presented at the workshop.

3. Acknowledgments

The support of the International Association for Fire Safety Science (IAFSS) is greatly appreciated for sponsoring this workshop. In particular, SLM would like to thank the program committee of the 12th IAFSS for the invitation to lead this effort, as well as the gracious support of Dr. Anne Steen-Hansen (RISE, Norway), and Dr. Tuula Hakkarainen (VTT, Finland), the co-chairs that assisted all of the Sunday workshops. Dr. Daniel Nilsson (Lund University, Sweden) is appreciated for locating a larger room for this event. Finally, Mr. Daniel Gorham (NFPA, USA), served as the official notetaker at the workshop, and his excellent help is most appreciated.

References

[1] Manzello S.L. (2014) Enabling the Investigation of Structure Vulnerabilities to Wind-Driven Firebrand Showers in Wildland Urban Interface (WUI) Fires, *Fire Safety Science* 11: 83-96, http://dx.doi.org/10.3801/IAFSS.FSS.11-83.

[2] Merci, B., Torero, J.L., and Trouvé, A., (2016) IAFSS Working Group on Measurement and Computation of Fire Phenomena, *Fire Technology* 52: 607. http://dx.doi.org/10.1007/s10694-016-0577-3

Appendix A: List of Presentations Delivered at the Workshop

Large Outdoor Fires and the Built Environment

Dr. Samuel L. Manzello[1,2,3]

[1]National Institute of Standards and Technology (NIST), USA

Reassigned to Japan
Invited Guest Researcher
[2]Building Research Institute (BRI), JAPAN
[3]National Research Institute of Fire and Disaster (NRIFD), JAPAN
samuelm@nist.gov

June 11, 2017

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FOR FIRE SAFETY SCIENCE

Special Thanks – Organizing Committee

- Dr. Tuula Hakkarainen (VTT, Finland)
- Dr. Anne Steen-Hansen (RISE, Norway)
- Dr. Daniel Nilsson (Lund University, Sweden)

Large Outdoor Fires

- Wildfires that spread into communities, known as Wildland-Urban Interface (WUI) fires have destroyed communities throughout the world
- Large outdoor fires that pose risk to built environment are urban fires in Japan

2014 Chile Fires

2016 Itoigawa City Fire

1995 Kobe Earthquake

1976 Sakata Fire

2015 Southern California Fires

Growing International Problem
Large Outdoor Fires

Canada 2016

USA 2016

Miyagi, Japan 2017

Growing International Problem

- Fire safety science research has spent a great deal of effort to understand fire dynamics within buildings
- Research into large outdoor fires is behind other areas of fire safety science research
- Due to the fact that large outdoor fire spread is incredibly complex, involving the interaction of topography, weather, vegetation, and structures

Large Outdoor Fires and the Built Environment

Objectives

- Presentations will highlight large outdoor fires throughout the world and explore synergies between these fires
- Specifically, each presentation will provide an overview of the large outdoor fire risk to the built environment from each region, and highlight critical research needs for this problem in the context of *fire safety science*
- The workshop will seek to develop the foundation for an international research needs roadmap to reduce the risk of large outdoor fires to the built environment
- This workshop will also provide a forum for *next generation researchers* to contribute to this important topic

Large Outdoor Fires and the Built Environment

Welcome and Workshop Objectives (5 min total)

Large Outdoor Fires and the Built Environment – European View (30 min total)
15 min oral presentation followed by 15 min open discussion on European View

Large Outdoor Fires and the Built Environment – Asian View (30 min total)
15 min oral presentation followed by 15 min open discussion on Asian View

Large Outdoor Fires and the Built Environment – North American View (30 min total)
15 min oral presentation followed by 15 min open discussion on North American View

Large Outdoor Fires and the Built Environment – South American View (30 min total)
15 min oral presentation followed by 15 min open discussion on South American View

Large Outdoor Fires and the Built Environment – Oceania View (30 min total)
15 min oral presentation followed by 15 min open discussion on Oceania View

Synergy Discussion (30 min total)

BREAK 2:30 PM

30 min final open discussion on synergies between all regions
Highlight research needs common to all regions

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Large Outdoor Fires and the Built Environment

Invited Panelists

- **Guillermo Rein (Imperial College London, UK)**
- **Eùlalia Planas (Politècnica de Catalunya·Barcelona Tech, Spain)**
- **Sayaka Suzuki (NRIFD, Japan)**
- **Pedro Reszka (Universidad Adolfo Ibañez, Chile)**
- **Raphaele Blanchi (CSIRO, Australia)**
- **Sara McAllister (USFS, USA)**
- **Michael Gollner (University of Maryland, USA)**

- **Daniel Gorham (NFPA, USA, volunteer note taker)**

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What Happens Next?

- NIST report will be issued – all presentations today
- Paper will be published highlighting the findings of this workshop
- Interested in having this a permanent working group as part of IAFSS?
  - Many expressed this desire – if interested to be a part of it see me
- ISO TC/92 Fire Safety
  - New task group (TG) started – ballot approved
  - Develop international standardization needs roadmap for this topic
  - Manzello leader – seeking technical experts to serve
    - If interested – see me

ISO

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Workshop on Large Outdoor Fires and the Built Environment

STATAMATER REVIEW OF EU WILDFIRES AND THE BUILT ENVIRONEMENT

Eulàlia Planas & Guillermo Rein

Universitat Politècnica de Catalunya Imperial College of London

Lund, 11th June 2017

UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH — Imperial College London

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12TH INTERNATIONAL SYMPOSIUM ON FIRE SAFETY SCIENCE — Workshop on Large Outdoor Fires and the Built Environment

Outline

1. **The Problem**
2. **The Solutions: Recent European research Output**
3. **Conclusions and Knowledge Gaps**

The Problem

Large outdoor fires affecting the built environment in the EU

- Natural risks:
  - Extreme geophysical events (earthquake, tsunamis, volcanic eruptions)
  - Meteorological events (storms)
  - Hydrological events (flood, mass movement)
  - Climatological events (extreme temperature, drought, forest fire)
- Technological risks (explosions, fires)
- Anthropic risks (terrorism, sabotage and deliberate damage, lack of basic supplies and services)

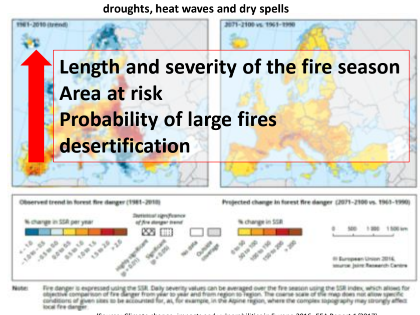
1st November 1755
Lisbon earthquake and tsunami followed by fire

(Source: https://horizon-magazine.eu/article/mapping-europe-s-earthquake-risk_en.html)

The Problem

Are WUI fires in EU really a problem or will they be in the future?

Climate change projections suggest substantial warming and increases in the number of droughts, heat waves and dry spells



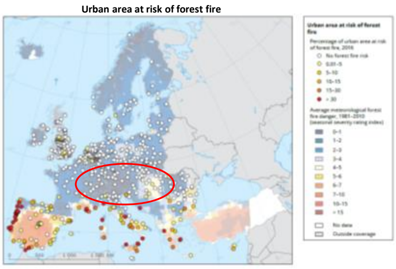
(Source: Climate change, impacts and vulnerabilities in Europe 2016, EEA Report 1/2017)

The Problem

Are WUI fires in EU really a problem or will they be in the future?

Urban sprawl with low-density housing into previous wild land, has increased the risk of forest fires in many residential areas over the last decades

Urban area at risk of forest fire



(Source: Climate change, impacts and vulnerabilities in Europe 2016, EEA Report 1/2017)

The Problem

EU definition of WUI

In Europe a common legal framework to define WUI areas does not yet exist

- There is no an harmonised definition of WUI at European level
- Every nation and region produces their own forest protection policies
- Buffer distances around urban settlements: 50-200 m
- Buffer distances around woody vegetation: 100-400 m

Country	WUI distances	Reference Law
France	100 m around urban areas, 200 m around vegetation areas	French Forest Law 9/July/2002
Italy	50-200 m around urban areas, 200-400 m around vegetation areas, depending on local region	Framework Law on Forest fire 2000/353 and regional plans
Portugal	100 m around urban areas, 200 m around vegetation areas. Intervention Priority zone	National Forest Law against forest fire 30 June 156/2004
Spain	50-100 m around urban areas, 100-400 m around vegetation areas, depending on local region	Ley de Montes 43/2003 and regional plans

(Source: Modugno et al., 2016; http://dx.doi.org/10.1016/j.jenvman.2016.02.013)

Gathering information on what happens in the WUI in a harmonized way is very difficult

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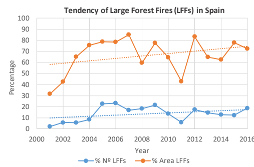
The Problem

Main characteristics of the WUI fires in Europe | MEDITERRANEAN

General characteristics of fires

- Mediterranean climate characterised by warm/hot and dry summers, but has also zones with semi-arid climate and oceanic climate.
- 90% of the burned area occurs during July to September. Tendency to prolong towards October and November.
- Portugal, Spain and Greece show a clear tendency to an increase in the percentages of large forest fires (LFFs), both in terms of number and area burned.
- Most of the Mediterranean territory has a problem of WUI.
- Often firefighting services are faced with the simultaneity of fires
- On the Mediterranean, fires are very dynamic and fast



(Data extracted from EFFIS System, http://effis.jrc.ec.europa.eu/)

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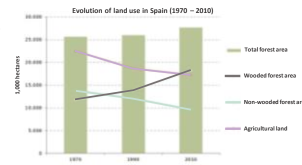
The Problem

Main characteristics of the WUI fires in Europe | MEDITERRANEAN

Main risk factors for WUI fires

- Recurrence of weather risk situations, increase the hydric stress and number and length of heat waves
- More intense fires due to more extreme weather conditions
- Depopulation of rural areas
- Increase of forested surface,(i.e. in Spain currently it represents 55% of the total, with an increase of 30% in the wooded forest area during 1990-2010)
- Increasing number of population in peri-urban areas
- Increase of isolated houses and residential areas through the forest
- Complex orography (Portugal)



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The Problem

Main characteristics of the WUI fires in Europe | PORTUGAL

Relevant WUI fires

Funchal (Madeira, Portugal), 8-10 August 2016

- 2000 ha burned
- 251 houses affected (154 destroyed)
- 3 deaths, 600 evacuated
- 154 M€ losses

- Heat wave and strong winds
- Simultaneous fires
- Poor accessibility to houses
- Artificial fuels everywhere
- Poor preparedness

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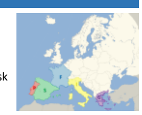
The Problem

Learning from past accidents



- Few attention has been devoted to the WUI problem
- No existence of complete and updated data on WUI fires
- Wildland-human interfaces (camp sites, music festivals,...) also a risk
- Effects on critical infrastructure. Regulations lack in LPG tanks and canisters
- Victims often are old people
- Fire propagation inside residential areas by spotting and enhanced by fuels stored everywhere
- Home owners along the Mediterranean coast coming from the north of Europe, with little knowledge about forest fires and perception of risk.
- Foreigners who do not know the language, they construct isolated wooden houses in the middle of the forest with difficult accessibility, without protection plan.
- Fire affecting the WUI are multi-emergencies that require lots of resources to protect people and assets.
- Safety distances are frequently not enough, prevention measures when building new structures are also required.

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The Problem

Learning from past accidents | Fires in northern latitudes

Vastmanland fire (Sweden), 31/7-4/8 2014

- 15.000 ha, largest forest fire in Sweden's modern history
- One thousand people were forced to evacuate
- The town of Norberg, with about 4500 residents, was being considered for evacuation. It has 17th century buildings and is popular with tourists and day trippers.
- One person was confirmed killed by the fire
- Fire entrapments of several volunteer fire-fighters
- Hot and dry weather exacerbated the fire, stressing vegetation.
- Record temperatures to many towns and cities (Sala city: 34.7 ºC)

Laerdal fire (Norway), 19/1-20/1 2014

- Fire devastated the historic town of Laerdal (Unesco World Heritage), consumed at least 30 buildings, injuring an estimated 100 people and destroying the village's signature wooden heritage (18th -19th century).
- Hundreds people had to be evacuated
- Preserved wooden houses and buildings make the town in western Norway a tourist attraction
- Fire began overnight in a house
- Strong winds allowed the Laerdal fire to move rapidly. The Laerdal fire coincided with a period of excessive warmth and drought

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The Solutions: Recent European Research Output

European Research

- We approached the leading centres of fire research in Europe.
- We asked for recent findings on WUI and projects.
- In total, we collected 10 responses which are summarized in the following slides.
- ADAI, CERTEC, Demeter, FSEG, INRA, Lund, PauCosta, UoE.
- This slides give a snapshot of the who and the what of EU WUI fire research.

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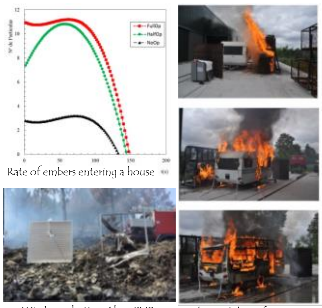
The Solutions: Recent European Research Output

ADAI, University of Coimbra, Portugal. PI: Prof. Domingos X. Viegas

- **Expertise:** Experimental fire behaviour at WUI.
- **Work:** Laboratory and field experiments to assess the resistance of structures (**WUIWATCH**).
- **Work:** Risk of fire in camping sites, burning of tents and caravans.
- **Output since 2010:** 2 papers and a *white book*.



Rate of embers entering a house

Windows shutter: Al vs. PVC

Flammability of Caravans

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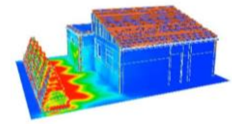
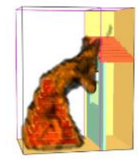
The Solutions: Recent European Research Output

CERTEC, Universitat Politècnica de Catalunya, Spain: PI: Prof. Eulalia Planas

- **Expertise:** Modelling and design for WUI fire.
- CFD modelling to explore house design, survivability, and alternative protection strategies.
- Aid identification of defensible/indefensible spaces and sheltering assessment.
- **Output since 2010:** 3 papers (more in preparation).



Temperature field predicted on WUI house.



Burning tree and flame impingement on window

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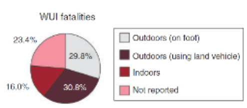
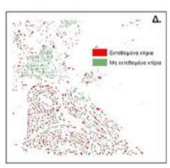
The Solutions: Recent European Research Output

***Demeter,* Hellenic Agricultural Organization, Greece. PI: Dr Gavriil Xanthopoulos**

- **Expertise:** Socio-economic factors + fire behaviour analysis.
- Wildfire and WUI fatalities.
- **Comparison of WUI in N America, Australia and Europe.**
- Threat analysis by remote sensing +fire behaviour.
- Social-ecological fire risk management.
- Prediction of economic losses.
- **Output since 2010:** 6 papers and a 1 book chapter.



WUI fatalities in Greece



WUI threat analysis

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The Solutions: Recent European Research Output

FSEG, University of Greenwich, UK. PI: Prof Ed Galea

- **Expertise:** Modelling of evacuation and building fires.
- **GEO-SAFE** project (H2020, 17 partners): network between Europe and Australia to work on wildfire suppression, life and goods protection, and training.
- Includes urban-scale evacuation simulation tools for planning and real-time management.
- **Output since 2010:** 2 papers.

Fire and evacuation simulation of the Bracknell fire, UK (2011).

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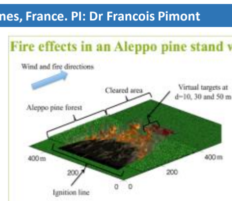
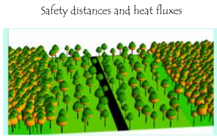
The Solutions: Recent European Research Output

INRA Ecologie des Forêts Méditerranéennes, France. PI: Dr Francois Pimont

- **Expertise:** Fire modelling for WUI protection.
- 3D modelling on impact of forest clearing and thinning and heat exposure.
- Impact of size and design of safety zones.
- Validation of radiative and convective fluxes.
- **Output since 2010:** 4 papers.



Safety distances and heat fluxes



Predicting effect of fuel treatments

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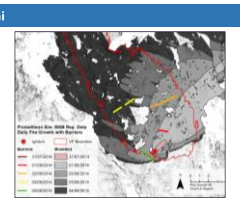
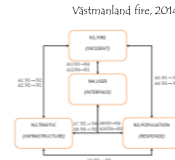
The Solutions: Recent European Research Output

Lund University, Sweden. PI: Enrico Ronchi

- **Expertise:** Modelling of evacuation and wildfires.
- 2D simulation of the Västmanland fire (Swedish largest WUI fire) and study of natural barrier.
- E-Murray (NIST funded): Coupling of fire, pedestrian and vehicle models to simulate WUI evacuation.
- **Output since 2010:** 1 MSc thesis.



Västmanland fire, 2014.



Fire, pedestrian and vehicle models for WUI evacuation

The Solutions: Recent European Research Output

Pau Costa Foundation, Spain. PI: Marc Castellnou

- **Expertise:** Socio-economic factors + fire behaviour of wildfires.
- Import **Firewise** (NFPA) from USA to the Mediterranean and help WUI neighbours:
- Support fire-fighters
- Citizens need to feel responsible for self-protection and cooperate.
- **Output since 2010:** 0 papers.

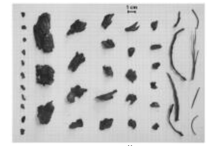
Signing agreement with NFPA

12TH INTERNATIONAL SYMPOSIUM ON FIRE SAFETY SCIENCE
Workshop on Large Outdoor Fires and the Built Environment

The Solutions: Recent European Research Output

BRE Center for FSE, University of Edinburgh. PI: Dr Rory Hadden

- **Expertise:** Experimental and modelling of fire behaviour.
- Burning dynamics of wildland fuels.
- Use of large-scale experimental fires to improve wildfire spread modelling.
- Production, and risks posed by, firebrands.
- **Output:** 4 papers.


Ember collected


3D modelling wildfires

12TH INTERNATIONAL SYMPOSIUM ON FIRE SAFETY SCIENCE
Workshop on Large Outdoor Fires and the Built Environment

Conclusions and Knowledge Gaps

Conclusions

- Compare to the scale of the problem, Europe pays little relative attention to **WUI fires.**
- WUI fires are getting worst all across Europe. Current risk is higher in the South but moving North.
- The number of WUI houses increasing. The frequency of extreme fire behaviour increasing (fuel accumulation, droughts, winds).
- Compared to N America and Australia, Med houses are less flammable (stone, brick and tile are traditional building materials).
- Difficulty in educating and preparing the public.
- Human dimension of WUI fires (migration out of wildland, migration into the WUI).

Knowledge Gaps

- Need for a European unified definition of WUI.
- Need a centralize and updated **database on WUI fires.**
- Need of a Mediterranean fire model to improve predictions.
- **Safety distances** are frequently not enough. How define them based on science and local conditions?
- Flammability of new materials (bio-based products, insulation).
- Is the policy of "Prepare and stay, or leave early" good for Europe?
- Need to raise public awareness of WUI fires. How?

LARGE OUTDDOOR FIRES AND THE BUILT ENVIRONMENT -Asia view-

Sayaka Suzuki
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Kuibin Zhou
Nanjing Tech University, China

Yulianto Nugroho
University of Indonesia, Indonesia

Where is Asia??

Asia

- Asia is large
  - 44,579,000 m^2
  - Large Continent & Islanc
- Population
  - 4.4 billion people
  - Densely or barely populated
- Variety of climate
- Variety of developments
  - even within counties
  - codes & standards
- Variety of culture
  - Different construction

How much is forest in Asia?

Large outdoor Fires in Asia

1987 Black Dragon Fire @ China & Russia

2010 Mount Carmel Fires @ Israel

Peat fires @ Indonesia

2016 Urban Fires @ Japan

2017 Shanty Town Fires @ Philippine

2000 Gangwon Wildfire @ Korea

Large outdoor Fires in Asia

- China – 1987 Black Dragon Fire, 2013 & 2014 Urban fires
- Indonesia – 1997 Indonesian Forest Fires, Peat fires, 2015 & 2016 Market fires
- Israel – 2010 Mount Carmel fires, 2016 (Nov) Israel fires
- Japan – 1995& 2011 Post-earthquake fires (2011 Tsunami fires), 2002 forest fire, 2016 Urban fire
- South Korea – 2000 Gangwon Wildfire, 2005 Yangyang fire, 2013 Pohang fire, 2016 Market fires
- Philippines – 2017 shanty town fires
- Russia- 1987 Black Dragon Fire, 2010(&2012) Russian fires

We did not know THAT kind of fire could happen in my country!

Large Outdoor Fires in Asia

- **Forest fires, Wildland fires, Wildfires or Mountain fires**
  - A lot of forest, and wildland
- **Wildland-Urban Interface (WUI) fires**
  - WUI area does exist
- **Urban fires**
  - Some countries have really-densely-populated areas

Disaster-related

- Earthquake
  - Post-earthquake fires
- Tsunami
  - Tsunami fires
- Flood, Cyclone, Typhoon

Mainly in Japan, and Japanese researchers have worked on those issues.

Less common for fires…

Large Outdoor Fires & the Built Environment – Asia view

Forest & Peat Fires in Asia – Problem

You will see a lot of presentations at IAFSS!

- **Peat Fires** - mainly Indonesia & Russia in Asia
  - Season is different, but both have large peat lands
  - Drought (& Global warming) making situation worse
  - Long & Slow flame spread (smouldering)
    - Producing lots of CO_2
  - Peat fire could cause another forest fires
- **Forest Fires**
  - Early Detection is the key – Airplane & Satellite
  - 1987 Black Dragon Fire showed 'the difference of making effort on forest fires'
- **Both Fires**
  - Haze issue
    - Causing health problem globally - for example from Indonesia to South-East Asia region

Large Outdoor Fires & the Built Environment – Asia view

Forest & Peat Fires - Research Needs

- Research on Ignitions, Detections, Flame (Fire) spreads, and Mitigations
- **Detection**
  - How soon it should be detected?
  - Can we tell the difference it is already ignited or will be ignited within a certain time?
  - Can we do something if detected sooner?
- **Mitigation strategies**
  - Based on scientific knowledge of ignition and flame spreads
  - not only effective but also **'eco-friendly'** not to cause any more health or environment issue in short term and long term
  - Cost is an important factor as peat lands are large
  - Possibility of re-ignitions after mitigation methods
- **Education**
  - How to prevent unintentional ignitions

Large Outdoor Fires & the Built Environment – Asia view

WUI fires in Asia - Problem

- **WUI area?**
  - 2010 Mount Camel **Forest** Fire - several village & people evacuated
  - More problems as people have more interaction with forest/wildland
- **WUI fires?**
  - Windy & Dry conditions
  - Korea had 2 WUI fires in one day (2013)
    - Korea national government designated the WUI
    - Areas located within 30m from forest
    - Temples, and cultural structure burned from forest fires
  - Almost happened in Indonesia (2016)
    - Forest and peat land fires spread to settlements
  - Japan's first two WUI fires happened in one day (2017)
    - Forest to residential fires & Residential to forest fires

Large Outdoor Fires & the Built Environment – Asia view

Urban fires in Asia - Problem

- Recent developments
  - **Co-existing New buildings & Old buildings**
    - New buildings follow (new) Codes & Standards
    - Old buildings – weaker to fire or any ignitions
    - Buildings under construction – weak to fire
  - Informal settlements exist in Asia
    - 2017 Shantytown fires in Philippines
- Most of '**urban fires**' – around 10 houses
  - something goes bad – 50 – 150 structures burned (2013 China, 2013 Korea, 2016 Israel, 2016 Japan)
  - Windy, dry, less firefighting
  - Spot fire – overwhelm fire fighters
  - **Simultaneous fires** in various spots by firebrands or anything
  - Effective Evacuation is a key to protect people

Large Outdoor Fires & the Built Environment – Asia view

WUI & Urban fires - Research Needs

- **Preparation**
  - Hazard Maps
    - Based on Scientific Research
    - Simulation & Model Prediction
- **Urban Planning**
  - Still in development means they may do something
- **Evacuations**
  - Correct Evacuation Spot
  - Including education to people
- **Real-time simulation – important in WUI & Urban Fires**
  - Predict fire spread within communities
    - Firefighters may use those simulations
    - Applying firefighting resources
    - Adjustable to simultaneous fires

Large Outdoor Fires & the Built Environment – Asia view

WUI & Urban fires - Research Needs

- **Applying** new Codes & Standards to new buildings
  - Take times
  - Strengthening firefighter technology is also a key
- **Retrofitting** the codes and standards
  - Existing buildings
    - Weaker to fire
    - Historical buildings with sprinklers
    - Structure Ignitions in urban/WUI fires
      - Mostly focus is on wooden buildings
      - Cost of adding fire protection system
      - What can we do while developing protections?

Overall Research Needs

- **Statistics** – how we consider all different aspects in Asia into statistics?
  - Economy is different
    - loss of 100 ha forest might means nothing to some country while that means a lot to others
  - Definition of 'Large fire'? Cost? burned area? Loss of life?
- **Long term & short term effect of anything**
  - long term effect still unknown
- **Health effect**
  - Lots of research going on
  - hard to even evaluate in short term and also how should we consider that into statistics?
- **Urban Planning & Fire problem**
  - How we solve the fire problem while waiting to have better urban planning or better fire-resistance technology applied (that takes time)

Large Outdoor Fires & the Built Environment – Asia view

Related Presentations at IAFSS

Some but not limited to …

- **Informal Settlement** Fires In South Africa: Fire Engineering Overview And Full-Scale Tests On "Shacks"(Monday, Oral)
- Experimental Study Of The Effect Of Water Spray On The Spread Of **Smoldering In Indonesian Peat Fires** (Tuesday, Oral)
- Review of Emissions of **Regional Haze** Episodes from Smouldering Peat Fire (Tuesday, Poster)
- Experimental Study of Heat and Moisture Migration of **Peat Bed** (Thursday, Poster)
- Characteristics of Firebrands Collected from Urban Fire – **Niigata Fire**, December 22nd 2016 (Thursday, Poster)
- Self-Ignition Of **Natural Fuels**: Can Wildfires Of Carbon-Rich Soil Start By Self-Heating? (Friday, Oral)

Large Outdoor Fires & the Built Environment – Asia view

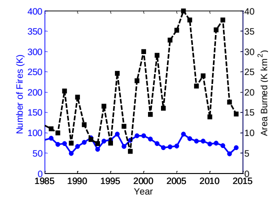
Large Outdoor Fires and the Built Environment – North American View

Sara McAllister (USDA Forest Service)

Michael Gollner (University of Maryland, College Park)

Fire Statistics

- United States
  - ~80,000 fires/year (relatively constant)
  - 1.6-4 million ha/year (apparent increasing trend)
  - ~95% of area burned by 3% of fires (historically relatively constant)
  - Suppression by: Federal (USDA, DOI), State, County, and City

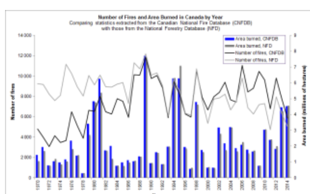


National Interagency Fire Center Statistics

Caton, Sara E., et al. "Review of pathways for building fire spread in the wildland urban interface Part I: exposure conditions." *Fire technology* (2016): 1-45.

Fire Statistics

- Canada
  - 9% of the world's forests, ~7,466 forest fires/year
  - ~2.5 million hectares burn annually
    - ~50% in remote "modified suppression areas"
  - 97% of area burned by 3% of fires.
  - Suppression costs: $500 million to $1 billion/year (last 10 years).



http://cwfis.cfs.nrcan.gc.ca/ha/nfdb?wbdisable=true

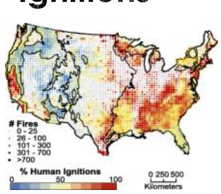
Fire Statistics

- Mexico
  - 8,013 fires/year from 1988-2004
  - 266,328 ha/year average from 1988-2004,
  - Average fire size from 1998-2005 is 33 ha
  - 84% human caused (agriculture ~43%)
  - "In Mexico, losses to structures and other infrastructure have not become a serious problem. While there are population centers within the forest areas that could be impacted by fires, they are usually surrounded by farming zones or the fuel loads have been reduced enough so that fires do not burn very intensely, if at all."

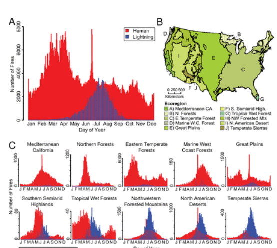
FAO (2006). Global Forest Resources Assessment 2005 – Report on fires in the North American Region. Fire Management Working Paper 15. www.fao.org/forestry/site/fire-alerts/en

Ignitions

Balch et al, PNAS 114(11): 2946-2951.



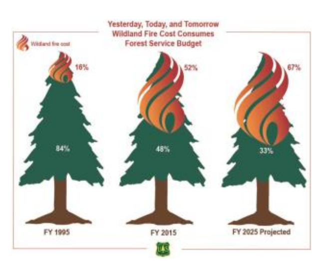
The total number of wildfires (dot size) and the proportion started by humans (dot color: red indicating greater number of human started fires) within each 50 km × 50-km grid cell across the coterminous United States from 1992 to 2012. Black lines are ecogregion boundaries, as defined in the text.



Frequency distributions of human and lightning-caused wildfires by Julian day of year. (*A*) Frequency distribution of wildfires across the coterminous United States from 1992 to 2012 (*n* = 1.5 million); (*B*) map of United States ecoregions; (*C*) frequency distributions of wildfires by ecoregions, ordered by decreasing human dominance.

The *real* wildfire problem

- USFS 78 million ha
- USFS alone spent $2.6 billion on fire management in 2015
- 1–2% of fires consume 30%+ of annual costs
- Less $ for FS other missions



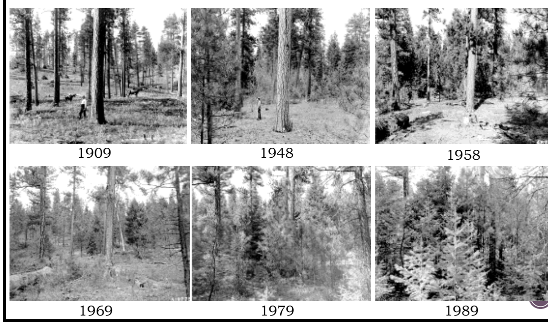
USDA, The rising cost of wildfire operations: effects on the Forest Service's non-fire work, Forest Service, Aug 4, 2015.

The cause

- Climate change
  - Longer, hotter, drier fire seasons
  - Drought, insects, and disease → higher mortality
- In US: 100+ years of fire exclusion
  - Very successful at suppressing small fires in mild to moderate conditions
  - Saves all the fires for the worst possible conditions
  - Historically, fires burned under wide range of conditions, sometimes quite frequently
    - Dramatic change in fuel loads, distribution, and composition
- Growth of the Wildland-Urban Interface
  - People are closer to wildlands
  - Ignition sources and communities are closer together

Photos from USFS: https://www.firelab.org/project/century-change-ponderosa-pine-forest

Fire exclusion – 80 years



Lessons learned from Yellowstone 1988

- 321,000 ha burned
- 9,000 firefighters
- 4,000 military
- ~$240 million in suppression

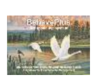
Photo from NPS: https://www.nps.gov/features/yell/slidefile/fire/wildfire88/crownfire/page-1.htm

Lessons learned from Yellowstone 1988

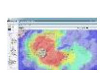
How do we put it back? And what does that even mean?

Photos from NPS: https://www.nps.gov/features/yell/slidefile/photopoints/Page.htm

Current tools in US



- Managers have dozens of models, tools, maps, data sources
  - Fire behavior
    - Prediction: BehavePlus, FARSITE, FlamMap, FSPro, Nexus, etc.
      - All based on Rothermel spread equation (1972)
    - Decision: WFDSS
    - Wind: Wind Ninja
    - Remote detection: Active burning (MODIS, VIIRS, airborne), post-fire consumption (dNBR)
  - Planning
    - Fire danger rating
    - Risk
    - Fuels management
  - Fuels
    - Current: Landfire, Landsat
    - Future: Forest Vegetation Simulator (FVS)
  - Effects
    - Mortality: FOFEM

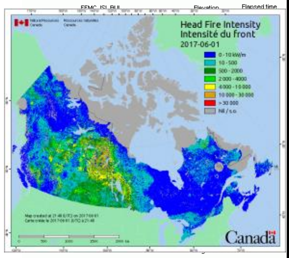


How they are used

- Operations (<<1%)
  - Predictions (specific)
  - Ensembles (probability)
  - Scenarios (what-if)
- Planning (>98%)
  - Risk (Monte Carlo, benefit-cost analysis, insurance, wildlife, community planning, etc.)
  - Fuels – primarily spatial planning (how much and where)
  - Fire management plans (seasons, zones)
- Training (~1%)
  - Curricula – S190, S290, etc.
- Historical reconstructions (?%)
- Research (?%)
  - Other tools: WRF-Fire, FDS, FireTEC

Current tools in Canada

- Canadian Forest Fire Danger Rating System (CFFDRS)
  - Fire Behavior Prediction (FBP) system (purely empirical)
- Canadian Wildland Fire Information System (CWFIS)
  - National Wildland Fire Situation Report
- Canadian Fire Effects Model (CanFIRE)
- Peatland fires and carbon emissions



http://cwfis.cfs.nrcan.gc.ca/home

Current tools in Mexico

- Wildland Fire Information System /Mexico
  - Natural Resources Canada, Canadian Forest Service - The Secretariat of Environment and Natural Resources (*Secretaría del Medio Ambiente y Recursos Naturales*, SEMARNAT-CONAFOR)
- Weather and Climate
  - National Commission of Water (CNA) - National Weather Service
  - Weather Center of Federal Electricity Commission - *Comisión Federal de Electricidad* (CFE)
  - Institute of Global Environment and Society (IGES)
- Detection and Monitoring of Forest Fires
  - National Commission of Knowledge and Use of Biodiversity (CONABIO)
  - National Forest Commission (CONAFOR) - Forest Fire Management Office - National Forest Fire Control Center (CENCIF) (daily report of heat points).
  - National Commission of Water (CNA) - National Weather Service and National Oceanic and Atmospheric Administration (NOAA).
  - Commission of Knowledge and Use of Biodiversity (CONABIO).

The WUI problem

- Chimney Tops 2 Fire
  - Gatlinburg, TN (2016)
  - 2,400+ structures destroyed
  - ~$500 million damage
  - ~$7 million suppression
  - 14 fatalities
- Cedar Fire
  - San Diego, CA (2003)
  - 2,200+ homes lost
  - ~$1 billion insured losses
  - $27 million suppression
  - 14 fatalities

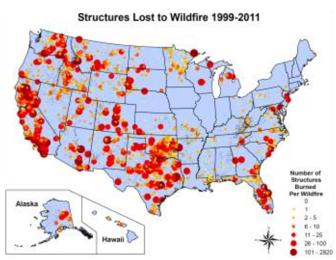


Figure: Fire Modeling Institute; Fire, Fuel, and Smoke Program; Rocky Mountain Research Station; Missoula, MT

Not just in the US

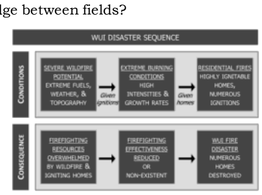
- Ft. McMurray Fire
  - Alberta, Canada, 2016
  - 2,400 buildings destroyed
  - $3.58 billion insured damages
  - ~$9.5 billion direct & indirect
  - 1.45 million acres
  - 2 indirect fatalities

Photo: Creative Commons

Unique Challenges & Opportunities in WUI

- WUI Disaster Sequence
- Blending of Fire Science and Wildland Fire
  - How do we translate knowledge between fields?

WUI disaster sequence. Each box corresponds to a factor that critically contributes to high numbers of destroyed homes during a WUI fire. Note that, if homes are ignition-resistant and numerous home ignitions do not occur (step 3), structure protection effectiveness is greater for home ignitions that do occur, thereby preventing disastrous losses.



Calkin, David E., et al. "How risk management can prevent future wildfire disasters in the wildland-urban interface." Proceedings of the National Academy of Sciences 111.2 (2014): 746-751.

Research groups

- US
  - Government agencies (NIST, USFS, USGS, NPS, BIA, BLM, DRI, EPA, NASA)
    - Researcher and funding sources
    - JFSP – 148 active projects
  - Universities
  - Private companies and consultants
- Canada
  - National Resources, Canada
  - Canadian Forest Service
  - Universities
- Mexico
  - Universities (esp. ecology)
  - Outside governments and NGOs

Current wildland/WUI fire research areas

- Experimental fundamental fire behavior
- Fire behavior model development and validation
- Fuels management effectiveness
- Fire fighter safety
- Risk
- Economics
- Emissions
- Remote sensing (pre- and post-burn fuels measurements, active fire behavior)
- Human behavior and social science
- Ecology (post-fire effects - mortality, seasonality, climate change, resilience)

Wildfire/WUI: Critical Research Needs

- How do fires spread?
  - Moving beyond local empirical fire models.
- Fire/atmosphere interactions
- Wildland-Urban Interface
  - Firebrands: Generation, ignition, transport
  - Firefighting, response and resilience
- Extreme fire behavior: trench effect, fire whirls, etc.
- Coupling remote sensing, emissions and operational model development (data assimilation, real-time modeling, etc.)
- Economic cost of suppression vs. effectiveness vs. risk
- Human and social dimension
  - Living with fire, evacuations, etc.
- Health effects

All important for both wildland and WUI fires!

Discussion

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www.combustioninstitute.cl

Large Outdoor Fires and the Built Environment - South American View

Pedro Reszka
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Overview of South America

- South America...
  - Is sparsely populated, with urban population (~80%)
  - Is poor, but becoming developed
  - Has weak, inefficient government institutions

	Population (×10⁶ inhab.)	Area (×10⁶ km²)	Pop. density (inhab./km²)	GDP (trillion USD)
South America	410	17.8	21.4	3.8
Europe	742	10.1	72.9	19.7
North America	565	24.7	22.9	21.2
Asia	4,164	44.5	87	18.5

2

Overview of South America

- Geography:
  - Andes mountains (2nd highest mountain range; Altiplano highlands)
  - Central lowlands, floodplains (Amazon basin, La Plata basin, Argentinean pampas)
  - Brazil-Guiana highlands
  - Patagonia
- Extremes:
  - Driest desert on Earth: Atacama
  - Wettest spots on Earth: Chocó, Colombia (>13,000 mm/year)

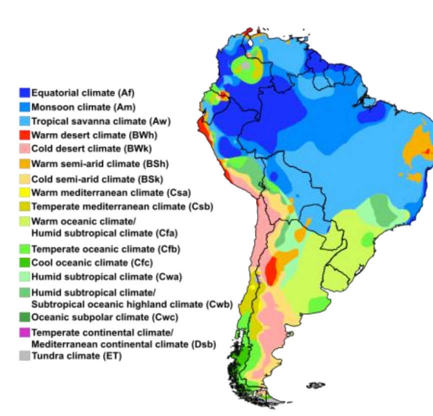
Map by Uwe Dedering,

3

Overview of South America

- Mainly tropical / subtropical climates
- Mediterranean climate in Chile's Central Valley
- Arid/semi arid in Atacama desert and Argentinean Patagonia
- Temperate/cool oceanic and cold desert climate in Patagonia

South America map of Köppen climate classification

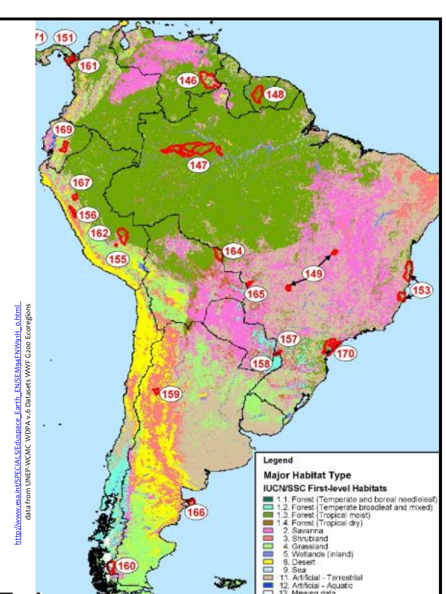


Map by Ali Zifan,

4

Vegetation in South America

- Tropical rainforests/deciduous forests in Brazil, Amazon region, Venezuela, Ecuador
- Temperate forests/rainforests in Southern portions of Brazil, Argentina and Chile (majority in Chile)
- Grasslands and shrublands are the largest land cover
  - Savannas in Brazil, Bolivia, Venezuela Colombia
  - Shrublands in Argentina - Chile
  - Grasslands in Argentinean Pampas
- Significant agricultural areas/tree plantations

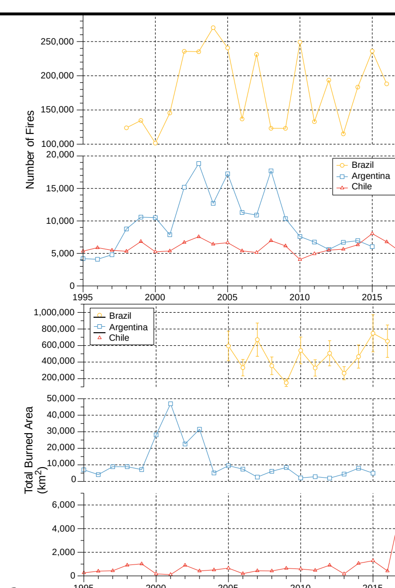


5

The Fire Problem: Statistics

- Data for 3 countries:
  - Argentina, Chile, Brazil (ABC)
- Data is hard to obtain
  - Statistics with high uncertainty, dubious
  - Brazil: satellite-based. Burn area estimates still being validated
  - Chile: best database
  - WUI-related incidents not well documented

	Population (×10⁶ inhab.)	Area (×10⁶ km²)
Argentina	43	2.78
Chile	17	0.76
Brazil	207	8.5



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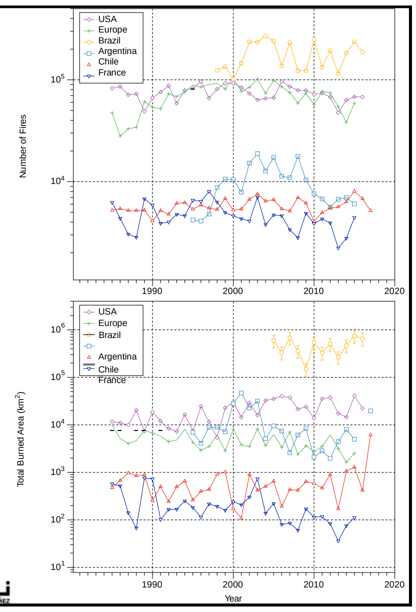
The Fire Problem: Putting it in Context

- Argentina: magnitude of burned area similar to Europe
- Brazil's wildfire problem is of greater magnitude than that of USA or Europe
- Chile: similar to France
- ABC: in general, larger % of land area
  - Inadequate/inefficient response?

	Burned Area (% of Land Area)
Argentina	0,41%
Chile	0,10%
Brazil	5,49%
USA	0,22%
Europe (25 countries)	0,093%
France	0,042%



7

WUI Fires

- Lack of specific statistics in Argentina, Brazil, Chile
- Argentina & Chile: several WUI fires in every season
  - Valparaíso: big problem
  - Many rural communities/ villages affected
- Most fires are human-related!

Some WUI Fires in Chile and Argentina		
Location, Year	Casualties	Losses
Quillón (2012)	2 dead	224 Homes. 1 paper pulp plant (>USD 160 million)
Chubut (2012)	-	7 Homes
Valparaiso (2013)	-	280 Homes
Valparaíso (2014)	-	20 Homes
Valparaíso (2014)	15 dead 500 injured	2900 Homes (> USD 110 million)
Valparaíso (2015)	33 injured	2 Homes
Chubut (2015)	-	5 Homes
Valparaiso (2017)	19 injured	140 Homes
Nilahue-Baraona / Las Máquinas (2016 - 2017)	11 dead	1012 Homes. 550,000 Ha burnt.
Viña del Mar (2017)	-	16 Homes

8

WUI Fires in Chile

- Most of the neighborhoods affected are mid-low income
- Many houses are built of light materials
  - Non-compliant with the building code
- Valparaíso: high presence of illegal landfills

9

WUI at Valparaíso - Ubeda & Sarricolea, Global and Planetary Change 146 (2016)

Valparaíso (2015), Intendencia de Valparaíso

The village of Santa Olga before and after the Las Máquinas fire, 2017 (EMOL)

Use of advanced tools for planning/response

- Pre-response is based on fire danger indices
- Risk-based tools
  - Not used by managers, local, national governments
  - Examples in research papers
    - Based on historical data, not predictions (i.e. no *fire science*)...
  - Confusion between fire hazards and risk
- Satellite-based information
  - Vegetation surveys
  - Fire detection
  - Response (International Charter)
  - Burnt area, burn scar estimations
- Fire modeling currently used in large wildfires by Chile's CONAF
  - Resource allocation and evacuation decisions

10

Bacani, Revista Árvore, Viçosa-MG, 40(6), p.1003-1011, 2016

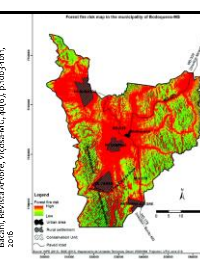


Figure 2 – Forest fire risk map in the municipality of Bodoquena-MS

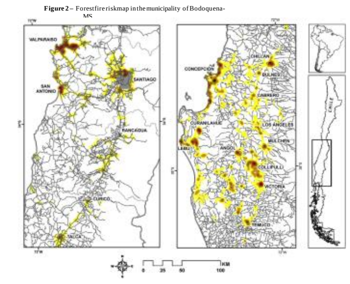


FIGURE 4.2 Location of the main areas at risk of wildfire, defined by critical areas with a past history of fire. Highest densities are shown in darker shades. Information processed by the Forest Fire Laboratory of the University of Chile.

Castillo et al., in: *Wildfire Hazards, Risks, and Disasters*, Elsevier (2015)

Research activities: Argentina

- Forest ecology: human, biophysical, environmental fire drivers
- Remote sensing: WUI mapping in Córdoba, calculation of burn probabilities, burn area estimation; fire frequency in Chaco region; use of spectral indices
- Fire science: FARSITE simulations of grasslands in Córdoba; development of parallel computing algorithms for wildfire modeling

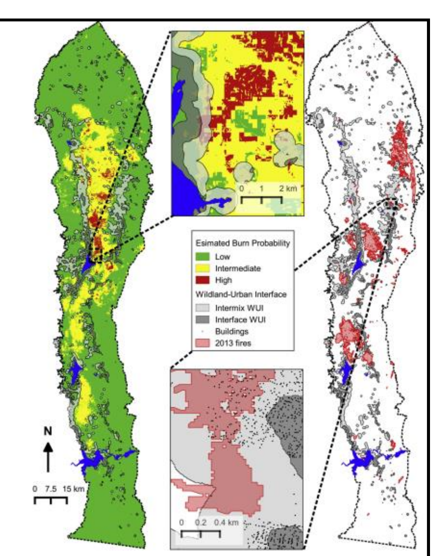


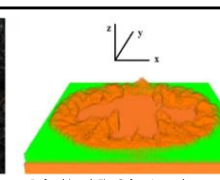
Fig. 5. Wildfire exposure assessment in the Wildland-Urban Interface of Sierras Chicas (Córdoba, Argentina) based on estimated annual burn probability derived predicting fire frequency (left) and incidence of the fires of 2013 on the WUI (right).

11

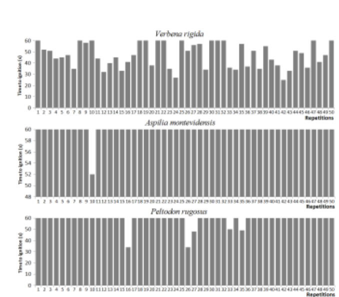
Argañaraz et al., *J. Environ. Manage.* 196 (2017) 499-510

Research activities: Brazil

- Largest wildfire community
- Land management tools: biomass quantification
- Atmospheric research: pollutant transport from wildfires
- Risk analysis: topographical aspects, road layout; fire probability maps (based on historical data)
- Forest ecology: impact of wildfires, global change
- Remote sensing: wildfire detection; burned area estimation
- Fire science: flammability of ornamental species; surface fire spread experiments in Amazonian forests; WFDS simulations of Amazonian forests; FARSITE/BEHAVE simulations of Brazilian savanna



Bufacchi et al, Fire Safety Journal 79 (2016)

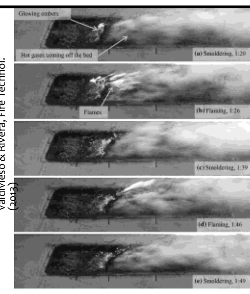


Biondi et al., Advances in Forest Fire Research, Viegas (ed.) (2014)

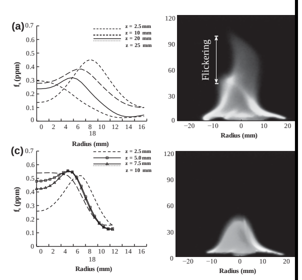
12

Research activities: Chile

- 4 active groups
- Ecology: effect of forest fires on dioxin/ furan concentrations in coastal waters
- Risk analysis: fire probability maps in the WUI (based on historical data)
- Remote sensing: Normalized Burn Ratio; use in fire risk analysis at the WUI
- Fire fighting support tools: KITRAL system
- Fire science: flammability/calorimetric testing of forest fuels, soot production measurements in flames; firebrand ignition; radiant ignition; wildfire forecasting with inverse methods; KITRAL fire model



Valdivieso & Rivera, Fire Technol. (2013)



Muñoz et al., Exp. Therm. Fluid Sci. 56 (2014)

13

Research community needs

- Increased numbers
- South American network
- R&D Funding:
  - Argentina: 0.64% GDP (2011)
  - Brazil: 1.2% GDP (2011)
  - Chile: 0.35% GDP (2012)
  - OECD average: 2.4% GDP

The town of Santa Olga (2017)

14

Research needs - building codes

- Responsibilities, jurisdiction
- Evolution to risk-based environment
- Flammability-based building material standards, reaction to fire tests
- Creation of a forensic task group (fire brigades + academia + forest service + regulators) to analyze major loss incidents at the WUI
  - Code/firefighting tactics improvement

The town of Santa Olga (2017)

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Research needs - WUI risk assessment

- National methodologies for wildfire risk estimation at the WUI
- Coupling of these methodologies to a national natural disaster risk system
  - Risk estimations from multiple hazards (e.g. tsunamis, volcanoes, fires)
  - Use of current infrastructure for tsunami risk estimations, modeling in the WUI case
- Use of remote sensing tools

The town of Santa Olga (2017)

16

Research needs - predictive capabilities

- Our view for the short term: local application of current models (e.g. FARSITE)
  - Long term view: use of physical models (CFD)
- Understanding the applicability of fuel models for local species using flammability tests and first principles
- Local validation of current models
  - Advantage: similarities between Chile & California!!
- Building a flammability data base for native/local species
  - Detailed measurements for CFD code validation (soot production, Tº fields, radical emissions, ignition delay times, HRRs, flame heights, MLRs)
- Ignition testing of building materials to develop vulnerability or dose-response functions (probits)

17

Research needs - predictive capabilities

- Understanding radiative transfer from flames
  - Soot production models, radiation models
- Understanding the fire behavior of native/local species under different stress conditions (e.g. several drought seasons)
  - Which species present a greater fire hazard?
  - How should forestry plantations be designed?
- Full-scale prescribed fires

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Research needs - firefighting tactics

- Urban fire brigades normally use structural fire tactics in WUI fires...
  - Effectiveness in severe incidents like Chile's 2016-2017 season
- Air-support: use of large tanker planes
  - Effectiveness in local geographies

Fire at a forestry plant near Constitución, Chile, 2017 (La Tercera/Agencia Uno)

The Global Supertanker and an Ilyushin 76 on the runway at Santiago's airport

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Acknowledgements:
Prof. C. Fernández-Pello
Prof. JL Torero
Prof. L. Figueira da Silva
Prof. G. Krieger
Prof. A. Fuentes
R. Leñam
J. Saavedra

Thank you !

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The Fire Problem

- Argentina:
  - Savanna grass- and shrublands: ~70% of burned area (2015, 2013 data)
  - Temperate/tropical forests ~25% of burned area
- Brazil:
  - *Cerrado* & *Caatinga* (tropical/dry savanna grass- and shrublands) ~65% of burned area (2005-2016 average)
  - Amazon: 26% of burned area
- Chile:
  - Forest plantations (*Pinus radiata*, *Eucalyptus globulus, E. nitens*) 23% of burned area (1985 - 2016 totals)
  - Temperate forests 21%
  - Shrublands 25%
  - Grasslands 24%
- Fire season:
  - Brazil: June - November (Austral Winter - Spring)
  - Argentina: September - February (Austral Spring - Summer)
  - Chile: December - March (Austral Summer)

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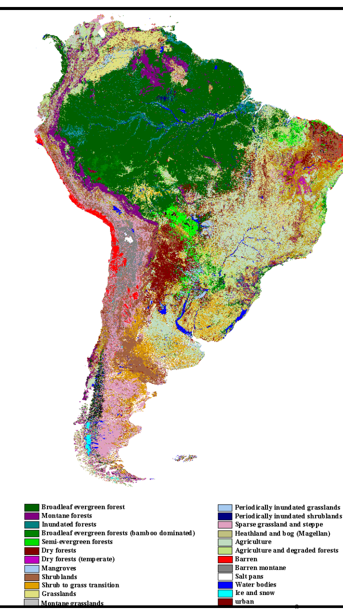
Vegetation in South America

- Forests occupy ~22% of South America
  - 27% of the World's total forest coverage
  - Major role in CO_2 cycle
  - Major industry
- Agricultural land: ~19% of total land area
- Rich & diverse ecosystems

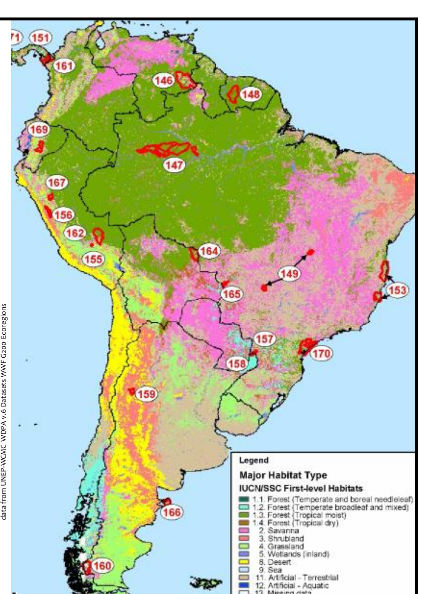


Eva et al., "A Vegetation Map of South America", EC Joint Research Centre (2002)

22

Vegetation in South America

- Tropical forests have not evolved facing natural forest fires
  - Low resilience
- Savannas (grasslands, shrublands) normally face natural fires
  - High adaptation, resilience to fires
- Chilean, Patagonian ecosystems are fragile to wildfires
  - Including shrublands
  - South Pacific High anticyclone prevents fre



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Fire Danger Rating Systems

- Brazil & Chile:
  - Fire Risk Index developed by Brazil's Space Agency, INPE
  - Based on rain data, weather forecasts
    - 7 types of vegetation
  - Results for South & Central America, Caribbean, Mexico
- Argentina: adopted Canada's FWI (Forest fire weather index)
- Chile: local fire danger rating based on weather conditions
  - Part of KITRAL, a Wildfire Management System

www.ushuaianoticias.co

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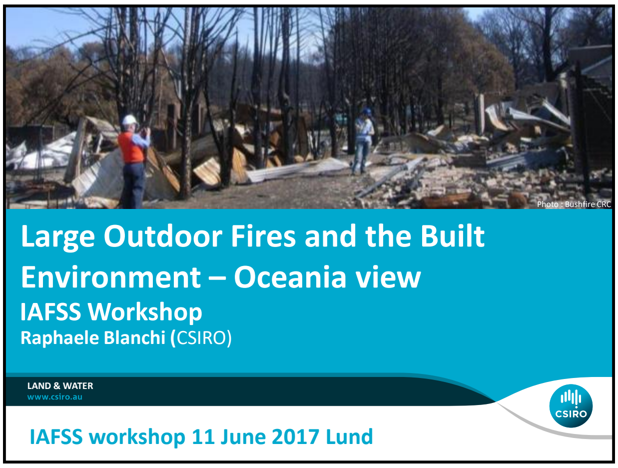
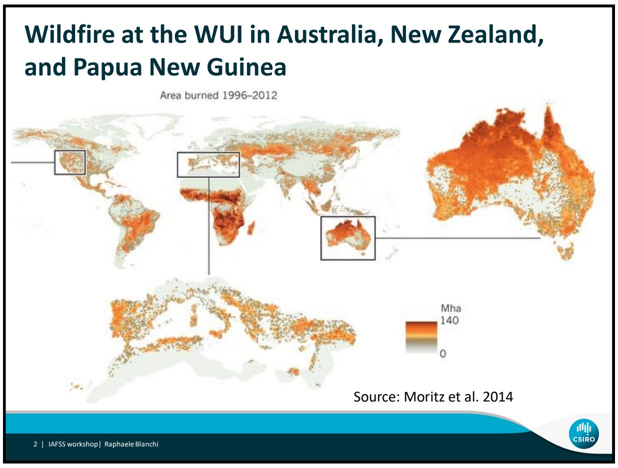
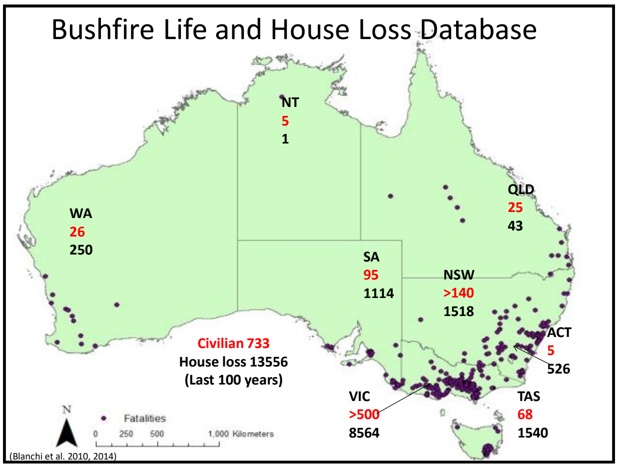
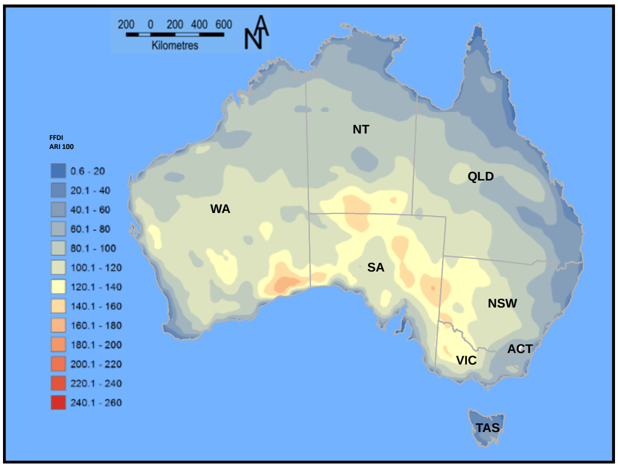
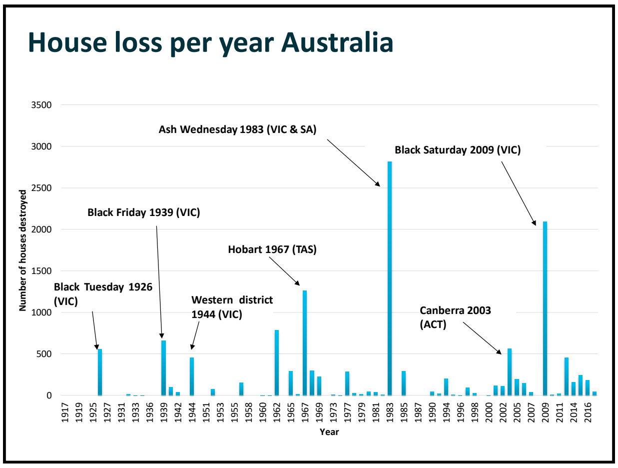
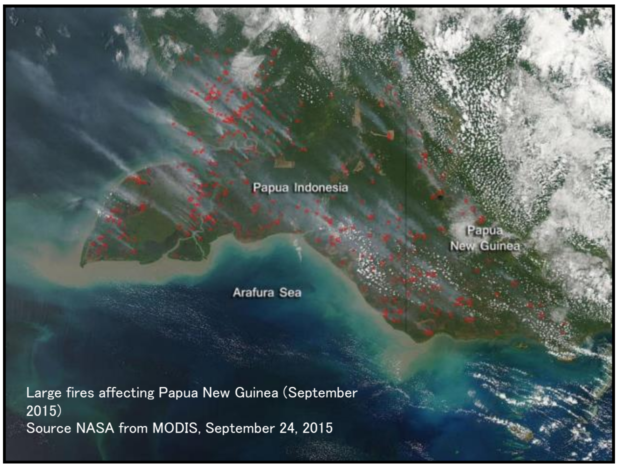

Large Outdoor Fires and the Built Environment – Oceania view
IAFSS Workshop
Raphaele Blanchi (CSIRO)
LAND & WATER
www.csiro.au
CSIRO
IAFSS workshop 11 June 2017 Lund


Wildfire at the WUI in Australia, New Zealand, and Papua New Guinea
Area burned 1996–2012
Mha
140
0
Source: Moritz et al. 2014
2 | IAFSS workshop | Raphaele Blanchi


Bushfire Life and House Loss Database
NT
5
1
QLD
25
43
WA
26
250
SA
95
1114
NSW
>140
1518
ACT
5
526
Civilian 733
House loss 13556
(Last 100 years)
VIC
>500
8564
TAS
68
1540
Fatalities
0 250 500 1,000 Kilometers
(Blanchi et al. 2010, 2014)


200 0 200 400 600
Kilometres
FFDI
ARI 100
0.6 - 20
20.1 - 40
40.1 - 60
60.1 - 80
80.1 - 100
100.1 - 120
120.1 - 140
140.1 - 160
160.1 - 180
180.1 - 200
200.1 - 220
220.1 - 240
240.1 - 260
NT
QLD
WA
SA
NSW
VIC
ACT
TAS


House loss per year Australia
Number of houses destroyed
Year
Ash Wednesday 1983 (VIC & SA)
Black Saturday 2009 (VIC)
Black Friday 1939 (VIC)
Hobart 1967 (TAS)
Black Tuesday 1926 (VIC)
Western district 1944 (VIC)
Canberra 2003 (ACT)


Papua Indonesia
Papua New Guinea
Arafura Sea
Large fires affecting Papua New Guinea (September 2015)
Source NASA from MODIS, September 24, 2015

Source: Photo by Kai Schwoerer/Getty Images

Port Hills Fire (New Zealand)	Number of house loss	Number of houses surveyed	Fatalities	Annual burnt area
13/02/2017	11	Inquest in progress	none	Fire season 15-16: 3500 ha Fire season 14-15: 3250 ha Fire season 13-14: 2000 ha Fire season 12-13: 4400ha

Better understanding of the risk at WUI

- **Many actors (Universities, research organisation, Bushfire and natural hazard CRC, AFAC, fire and forest services, consultants,…)**
- **Better understand life and structure loss in bushfires :**
- Historical fire data
- Spatial data (remote sensing and GIS)
- Evidence from post bushfire surveys (building and interviews)
- Experimental work to understand the performance of different material and system

(Photo source Bushfire CRC)

Post bushfire surveys

(Photo source Bushfire CRC)

Fire Ash Wednesday (Australia)	Burnt area	Number of house loss	Number of houses surveyed	Fatalities	State	Weather	Cost
16/02/1983	210,000 ha	1511 VIC	1153 (in Victoria)	47 (Vic) 28 (SA)	VIC SA	FFDI 130	$400M

.g. Ramsay et al. 1987)

Canberra (Australia)	Burnt area	Number of house loss	Number of houses surveyed	Fatalities	State	Weather	Cost
18/01/2003	160,000ha	519	226	4	ACT	FFDI 100	$350 M

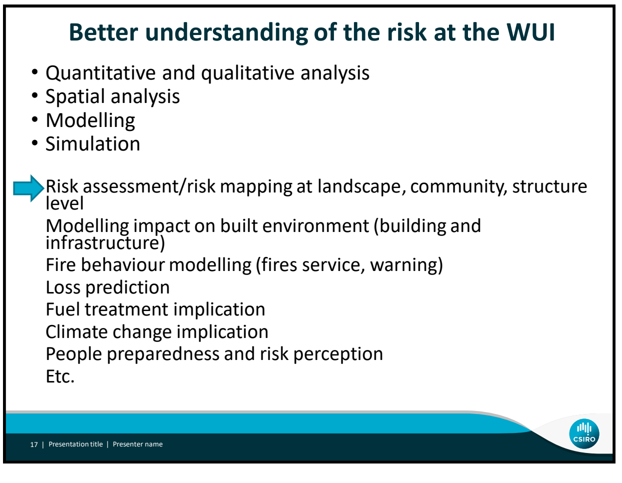
~80-90% of house destroyed in absence of direct radiant heat and flame from the fire front

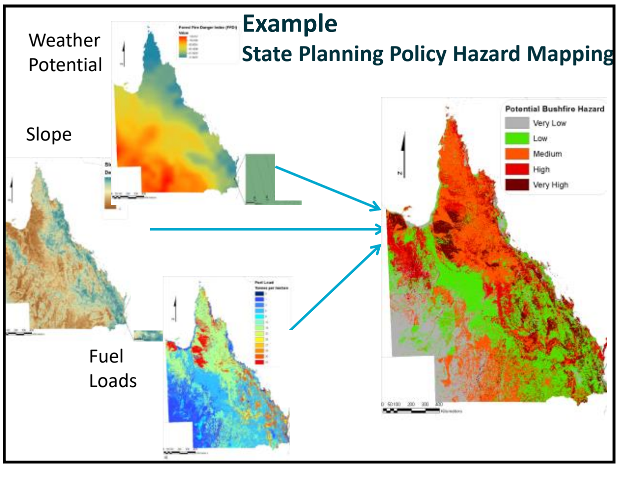
(e.g. Leonard et al. 2005)

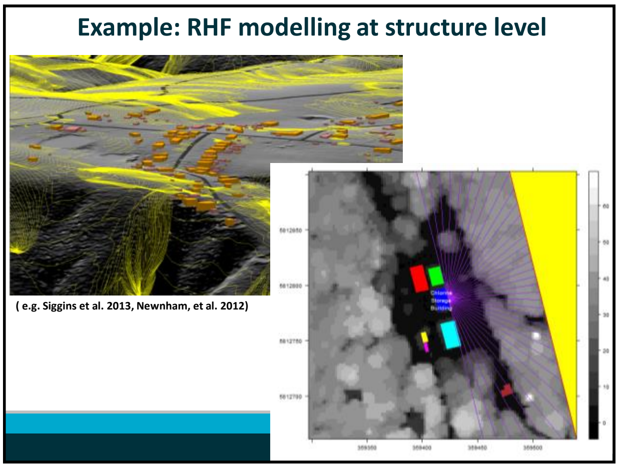
Influence of surrounding object

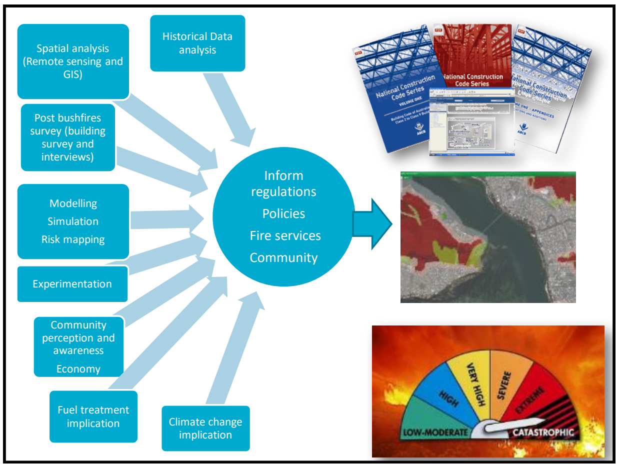
Photo: CSIRO

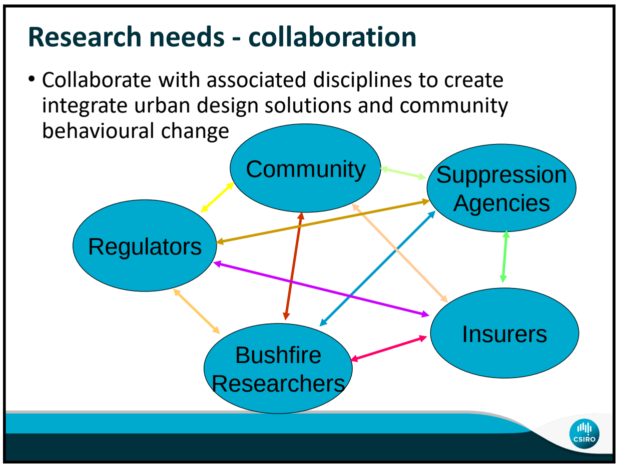
Black Saturday (Australia)	Burnt area	Number of house loss	Number of houses surveyed	Fatalities	State	Weather	Cost
07/02/2009	390,000ha	2100	1100	173	VIC	FFDI 155	>$4B






Example: RHF modelling at structure level
(e.g. Siggins et al. 2013, Newnham, et al. 2012)


Spatial analysis (Remote sensing and GIS)
Historical Data analysis
Post bushfires survey (building survey and interviews)
Modelling
Simulation
Risk mapping
Experimentation
Community perception and awareness
Economy
Fuel treatment implication
Climate change implication
Inform regulations
Policies
Fire services
Community
LOW-MODERATE
HIGH
VERY HIGH
SEVERE
EXTREME
CATASTROPHIC


Research needs - collaboration
• Collaborate with associated disciplines to create integrate urban design solutions and community behavioural change
Community
Suppression Agencies
Regulators
Insurers
Bushfire Researchers


Research needs
• Towards community adaptation: willingness to accept fire as inevitable process
• Study ways to understand the community motivations and attitude to effectively adapt to fire
• National and international datasets
• Damage
• Ignition point, etc.
• Better understanding of the exposure
• Better assessment of fuels load (to improve fire behaviour, and fuels management)
• Improve future weather quantification
• Less vulnerable urban area
• Fire adapted landscape that moderate fire as it approaches (ornamental vegetation, surrounding object)
• Building
• What measures are most effectives?
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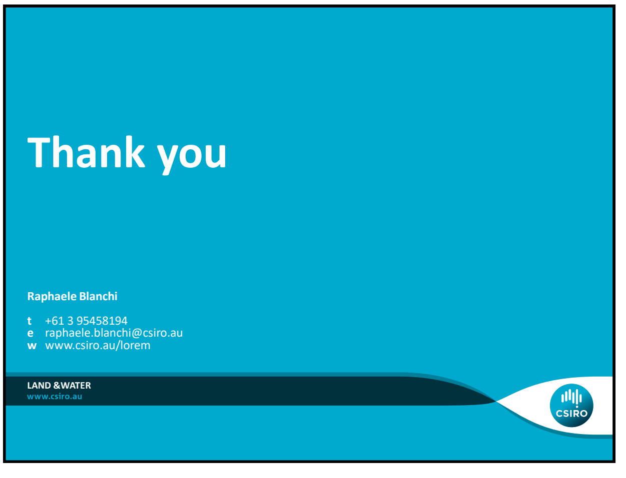
Thank you
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