Application of wildfire spread modeling to quantify wildfire impacts at WUIs

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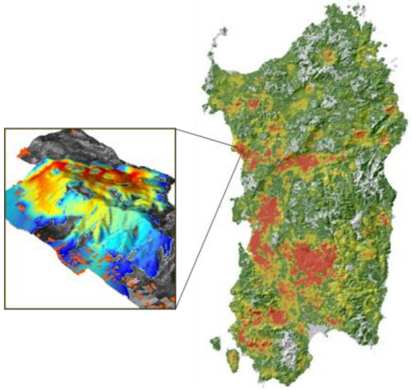
Foreword

- ❑ Few large wildfires (1-2%) responsible for the most of area burned (50-80%) and impacts

- ❑ "Worst" wildfires: extreme weather and fuel conditions, spread for large distances, simultaneous events, fire suppression capacity overwhelmed

- ❑ Expansion of WUIs = More wildfire impacts and losses

- ❑ Defining risk management strategies is challenging (e.g. land aband., budget limit., climate ch., etc.) but can be supported by wildfire spread modeling



Wildfire Risk

Finney 2005; Miller and Ager 2013

Expectation of losses (or benefits) from wildfires

Quantitative assessment of risk includes wildfire behavior probabilities and consequences

RISK = Probability × Consequences

Effects = Intensity × Susceptibility

$$E(NVC_j) = \sum_i p(f_i) \times RF_j(f_i)$$

Expected Net Value Change (% yr^{-1})

Annual **burn probability** at the *i*-th fire intensity level

Response/**effect** on resource *j* as a function of the *i*-th fire intensity

Using monetary units, we can estimate expected economic losses (€ yr^{-1})

Wildfire Risk

Finney 2005; Miller and Ager 2013

$$E(NVC_j) = \sum_i p(f_i) \times RF_j(f_i)$$

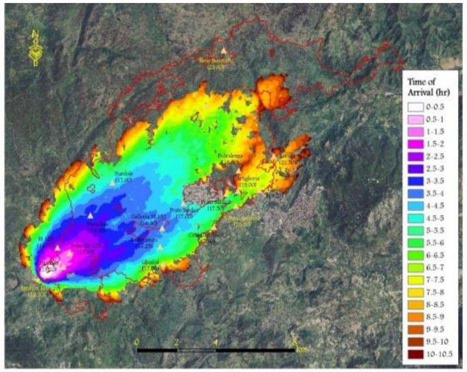
We sum over *i* because a wildfire can spread at different intensities for a given site

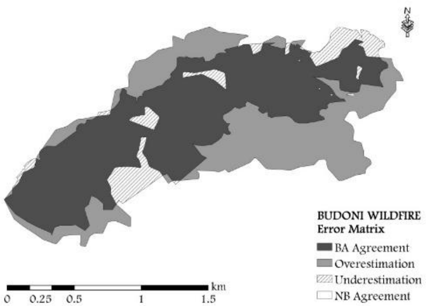
Note that:

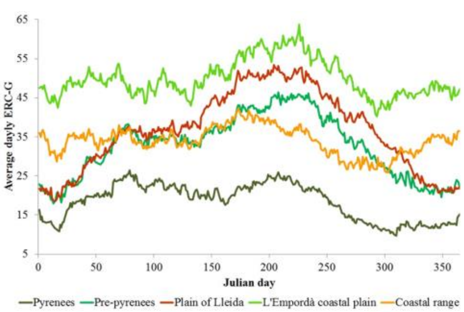
- Wildfire risk is not an index
- A fire ignition does not necessarily pose a risk
- Ignition probability ≠ burn probability
- Large set of wildfire perimeters and data to assess risk (historical data insufficient and do not cover all scenarios)

Wildfire spread models allow to characterize and measure wildfire spread and behavior features by taking into account a number of conditions/scenarios

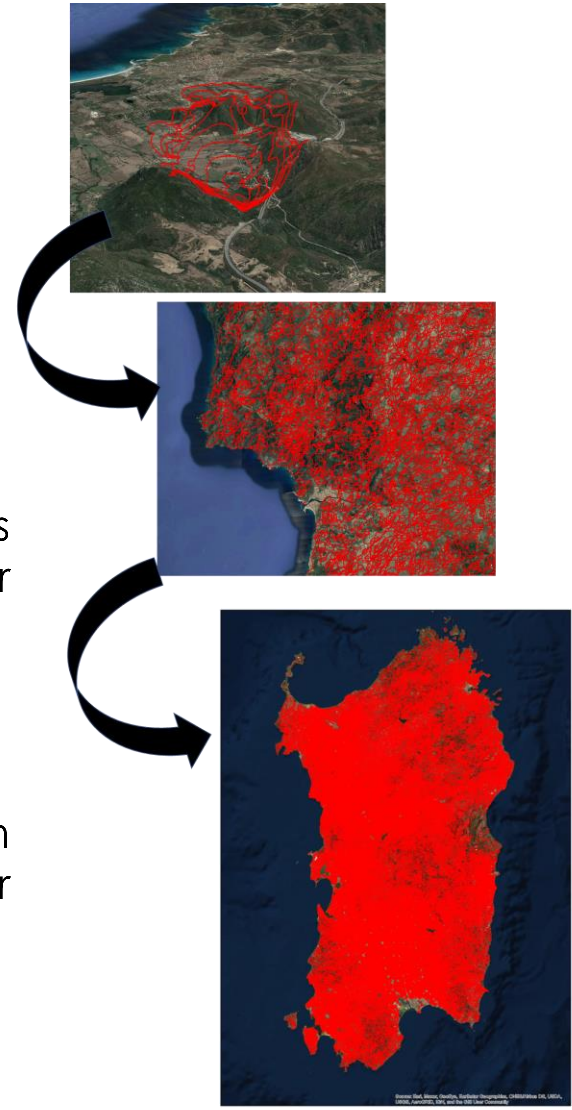
Wildfire spread models







- ❑ Preliminary calibration and validation
- ❑ Simulation of thousand wildfires
- ❑ Stratification of fire-weather scenarios according to historical frequency for homogeneous areas
- ❑ Replication of wildfire ignition probabilities and burning periods, for each given fire-weather scenario
- ❑ Modeling single wildfires randomly drawing from the above inputs



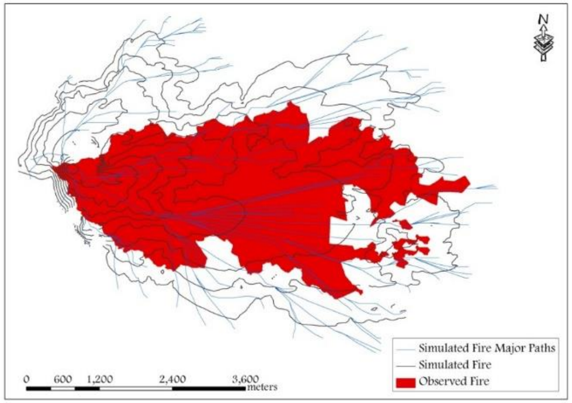
300,000 wildfire simulations

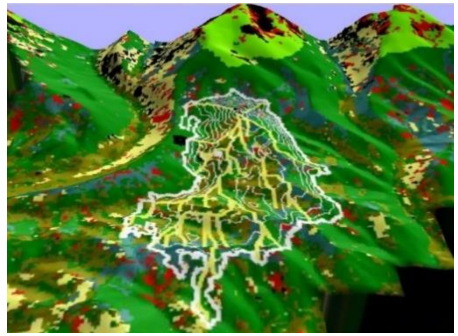
(Salis et al. 2021)

Wildfire spread models

(Finney 2002)

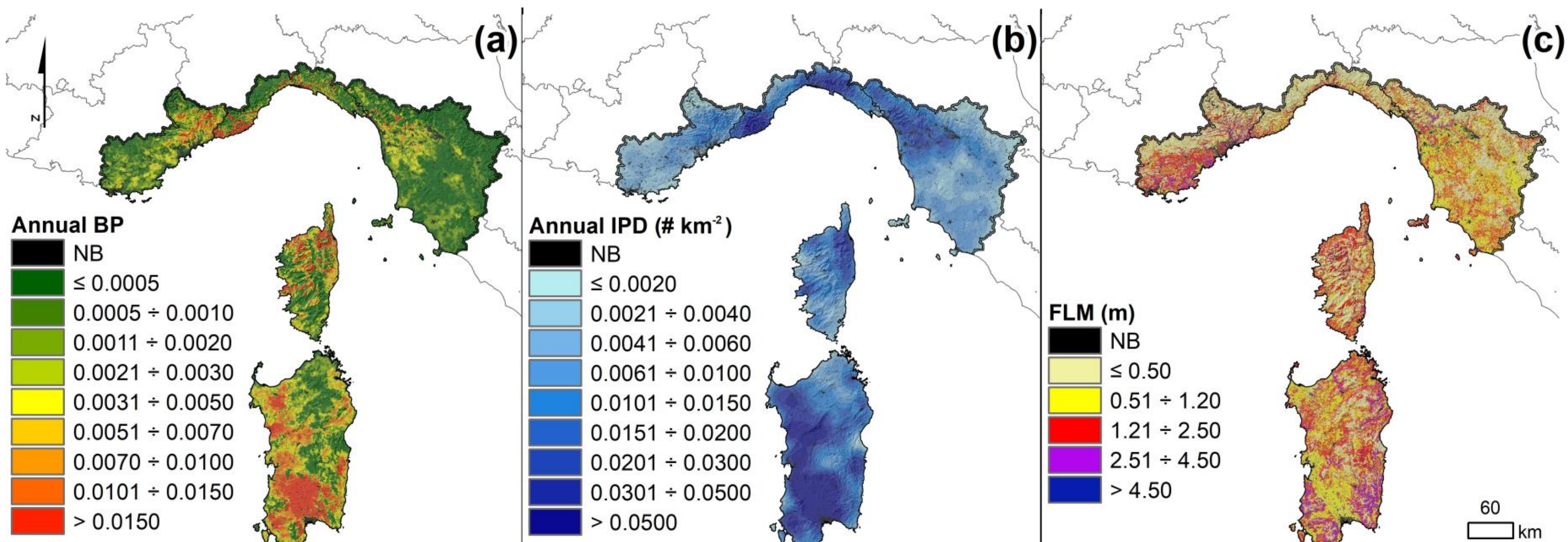
Minimum Travel Time





Quickest path and minimum time for a fire to travel among nodes on the landscape

Computationally feasible to simulate thousands of wildfires and generate burn probability and intensity maps over large areas

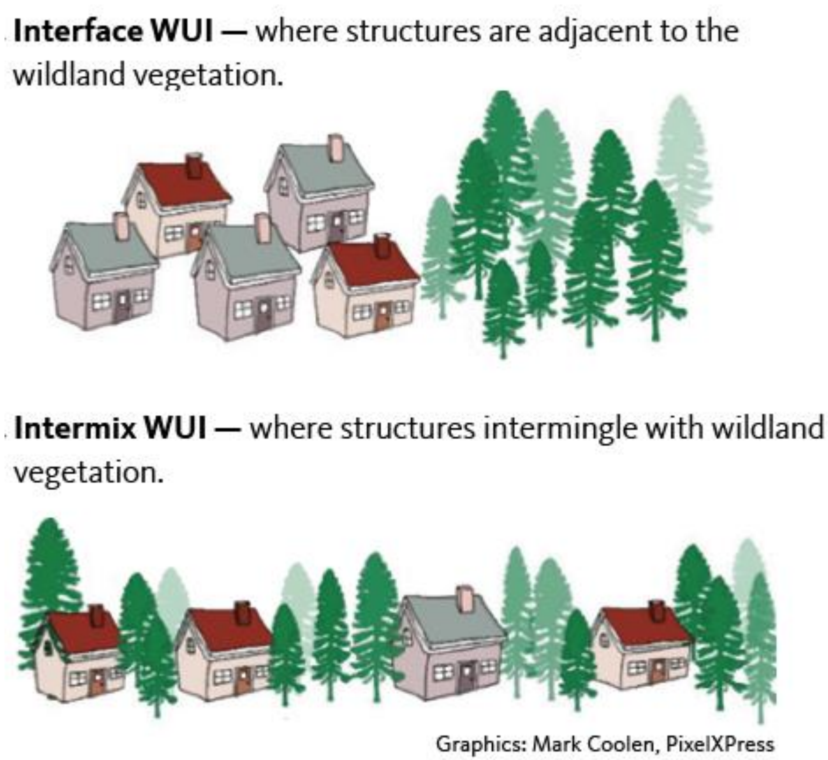


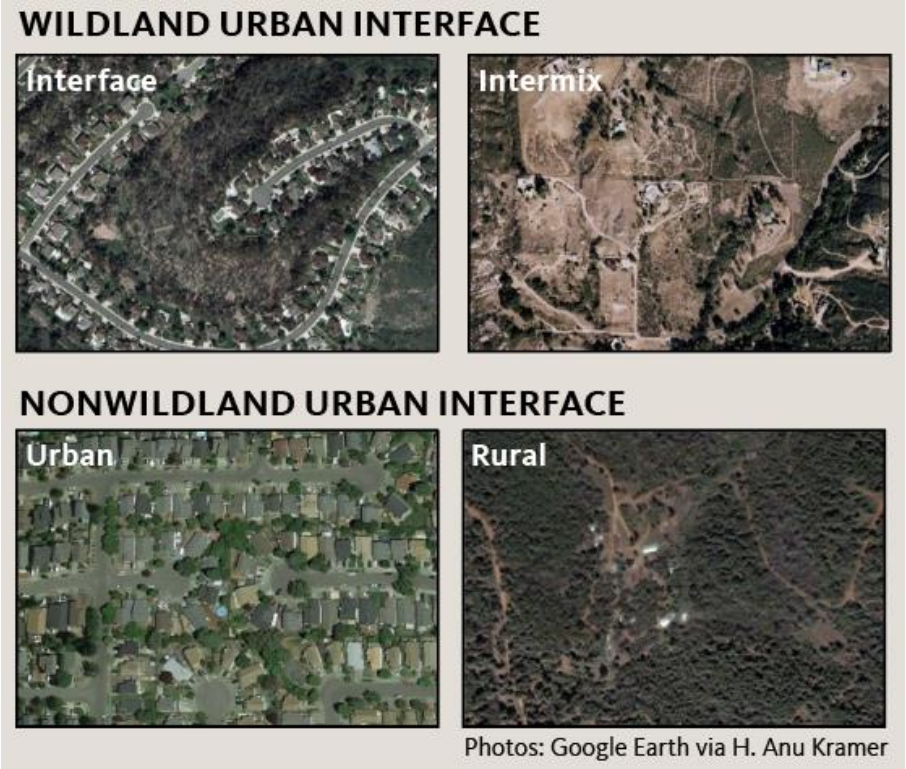
(Salis et al. 2023)

How to identify WUIs areas and estimate wildfire impacts?

WUI: any area where humans and their development meet or intermix with wildland fuel (USDA Forest Service)

[OSU Extension Catalog]





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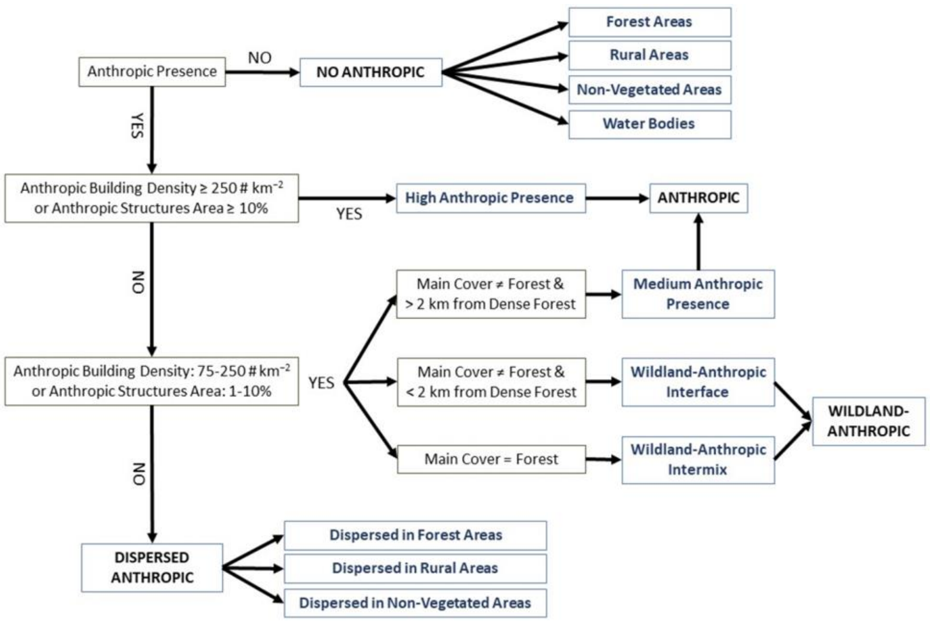
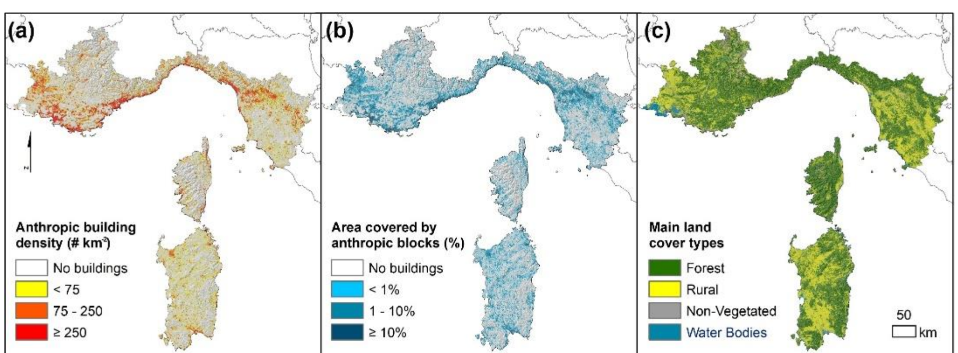
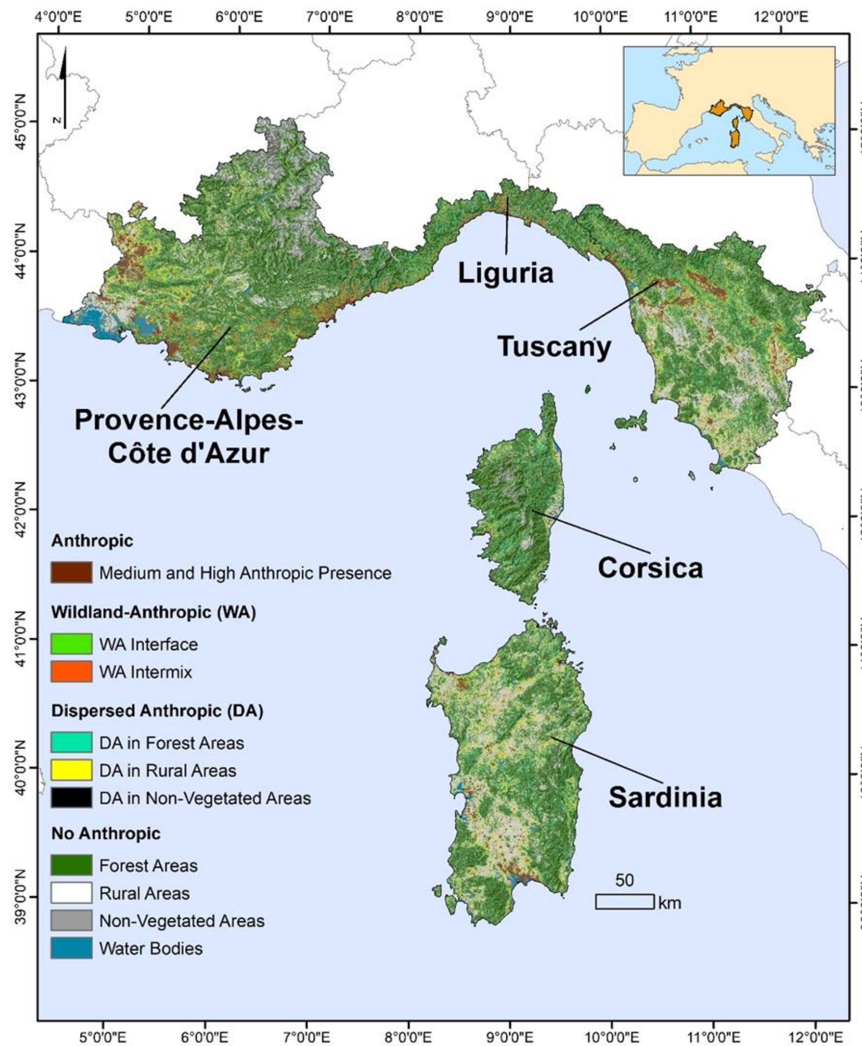


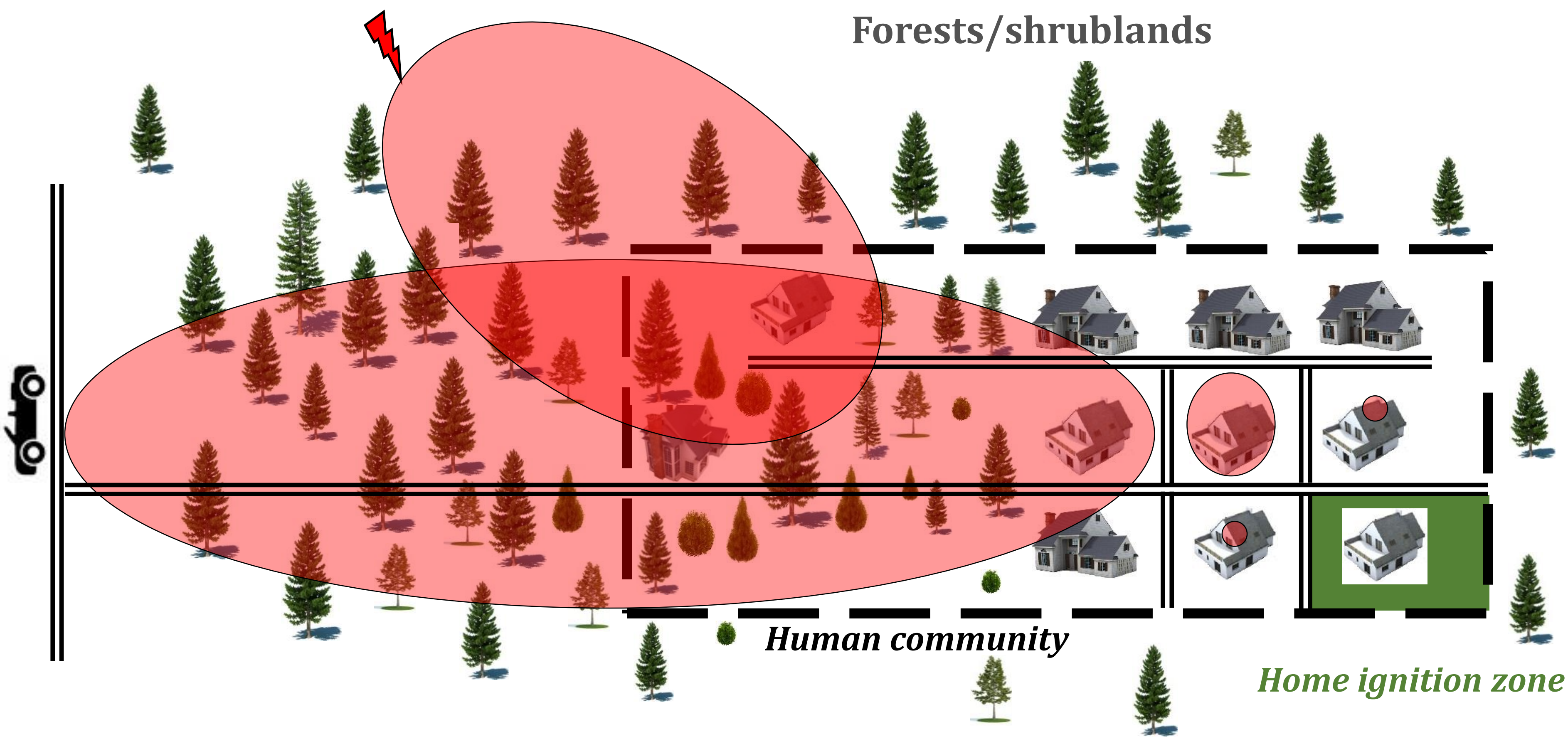




(Del Giudice et al. 2021)

How to identify WUIs areas and estimate wildfire impacts?

How wildfires impact human communities and WUIs

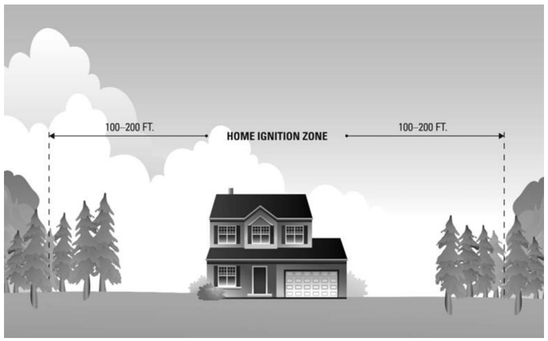


(Alcasena 2018)

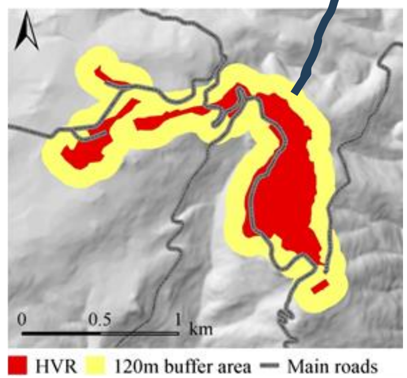
How to identify WUIs areas and estimate wildfire impacts?

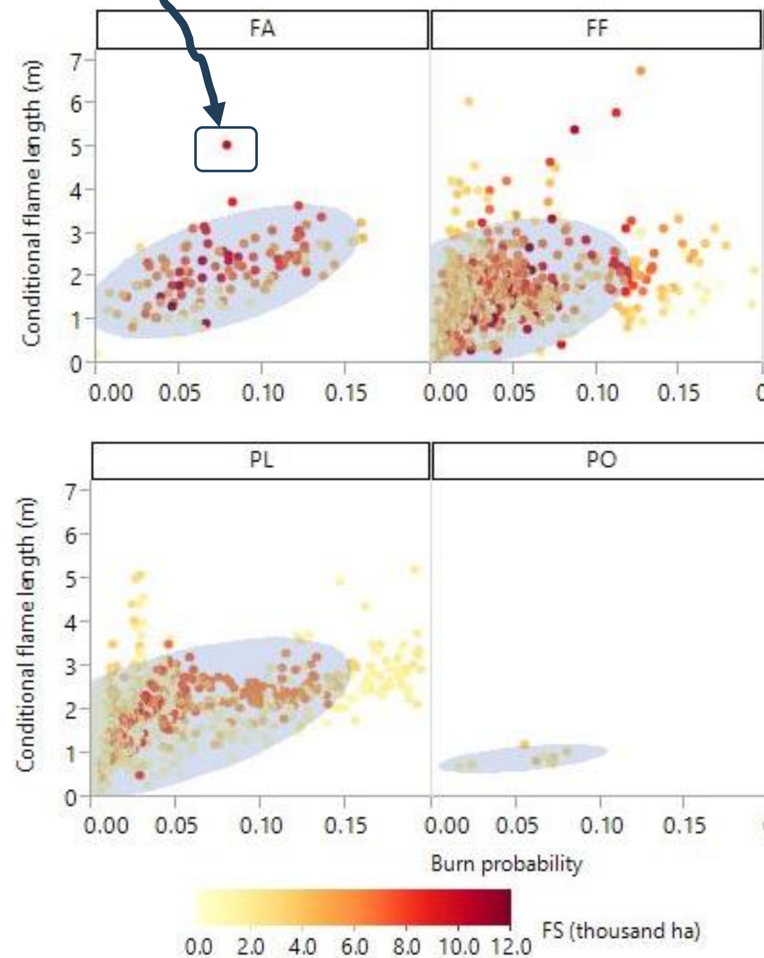
1) Home Ignition Zone (HIZ)

Each point is a given HIZ



(Cohen 2008)





(Alcasena et al. 2015)

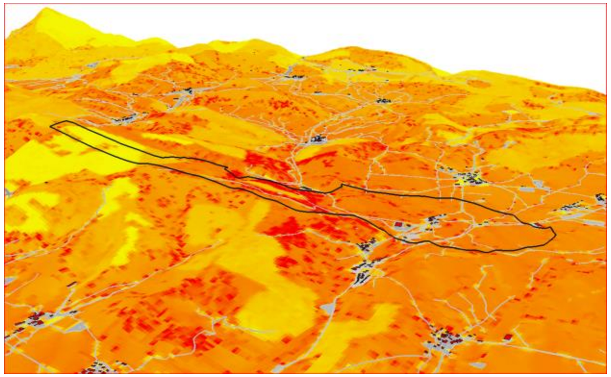
Buffer nearby an anthropic building

Intersection with wildfire spread modeling outputs

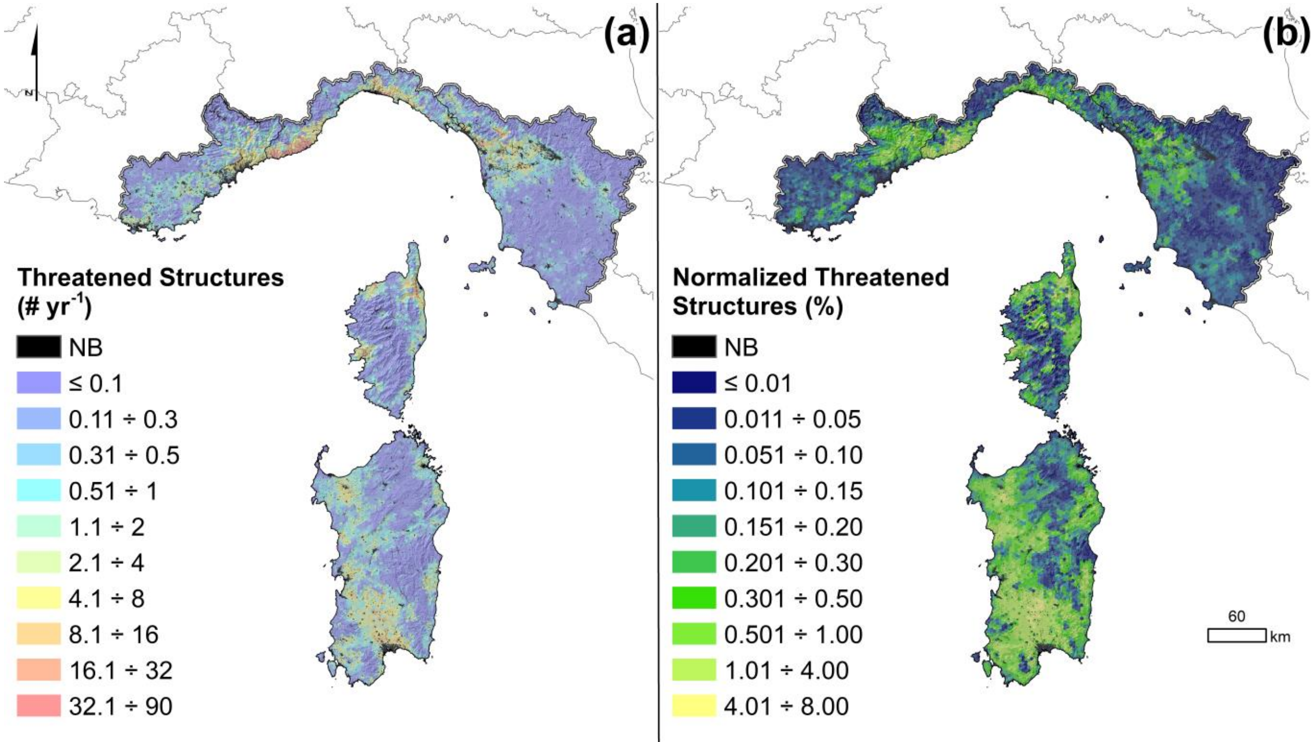
Characterization of wildfire behavior at HIZ level

How to identify WUIs areas and estimate wildfire impacts?

2) Buildings Centroids/Perimeters



Intersection of building centroids or with simulated wildfire perimeters and behavior features



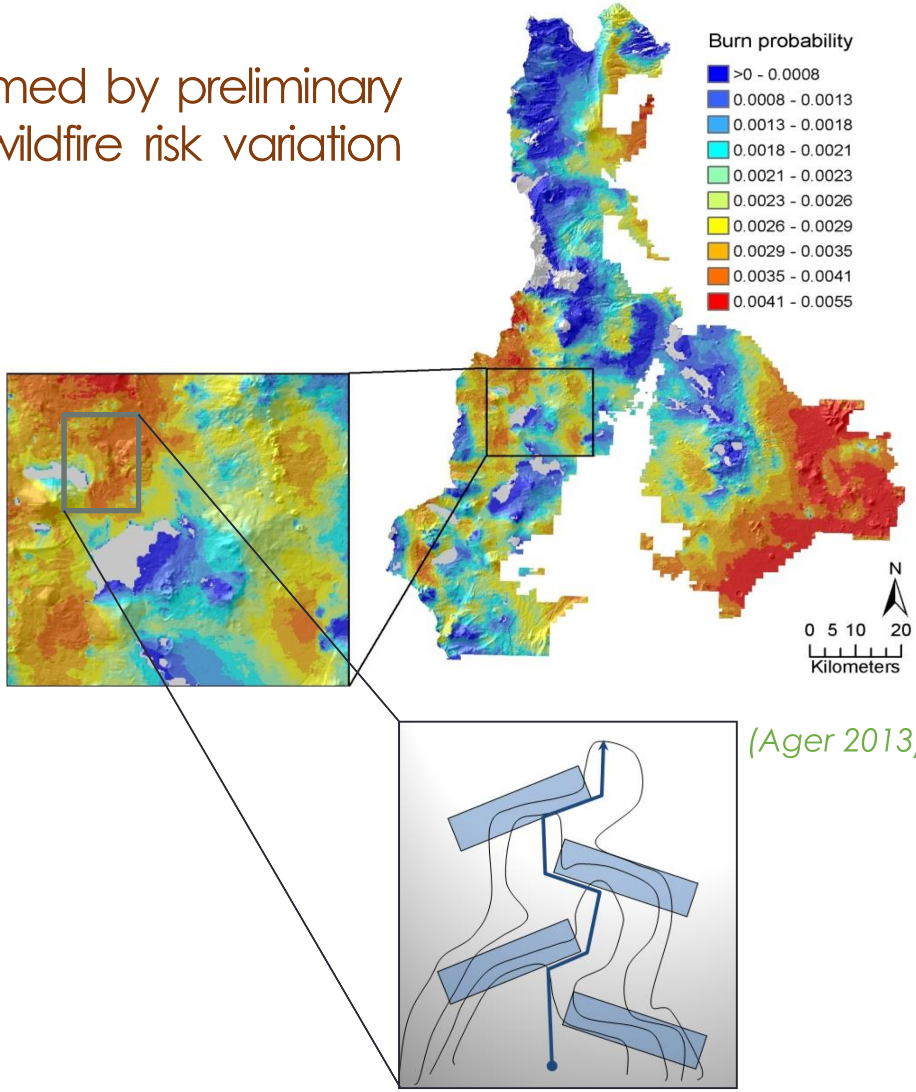
(Alcasena 2018; Salis et al. 2023)

Key points for wildfire risk management at WUIs

Wildfire prevention activities can be informed by preliminary assessment of wildfire behavior and of wildfire risk variation after treatments

<u>Designing</u> prevention projects requires understanding how the proposed treatment affects:

- Spatial variation in risk
- Risk transmission
- Potential to manage



(Ager 2013)

Fuel Treatment Effects on Fire Growth

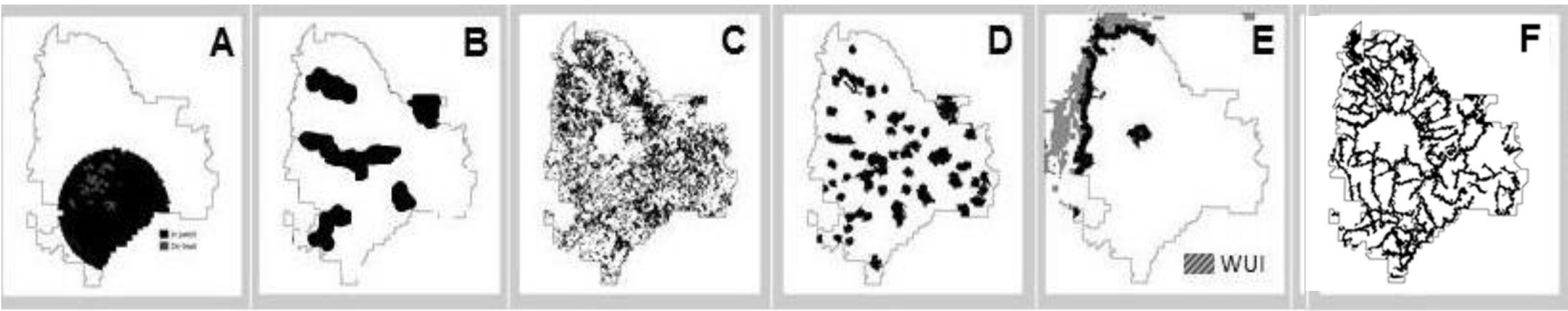
Key points for wildfire risk management at WUIs

Spectrum of fuel management strategies

Lower fire intensity — Lower burn probability & spread potential

Restoration → Protection & Containment

Low hazard fire containers	Strategic restoration of natural barriers	Broad landscape protection (TOM)	Dispersed defensible fuel breaks	Localized defensible fuel breaks	Strategic containment at defensible areas

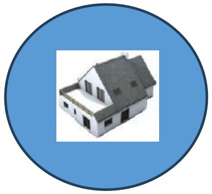


Black areas represent fuel treatment units

(Ager 2013)

Wildfire risk management in Sardinia WUIs

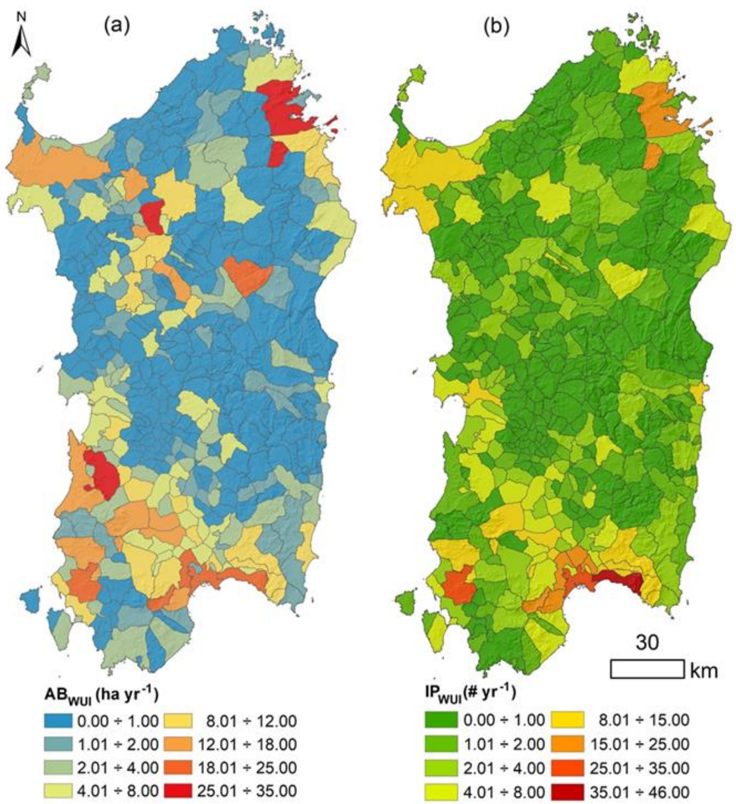
Wildfires at WUIs in Sardinia (HIZ = 100 m)



Study period 2005-2019

On average, about 818 wildfires yr^{-1} and 995 ha yr^{-1}

Wildfires at WUIs ≈ 27% of the total fire ignitions and ≈ 7% of the total area burned



Need of identifying "hot spot" areas and planning fuel treatments in WUIs as well as in wildlands or rural areas

(Scarpa et al. 2024)

Wildfire risk management in Sardinia WUIs

Fuel Management Plans


Progetto pilota di creazione di best practice:
pianificazione e gestione a livello comunale di interventi di preparazione annuale del territorio per la prevenzione antincendio.
Messa in sicurezza del territorio comunale di Bonorva

Piano di azioni di preparazione del territorio

Primavera 2023

Comune di Bonorva

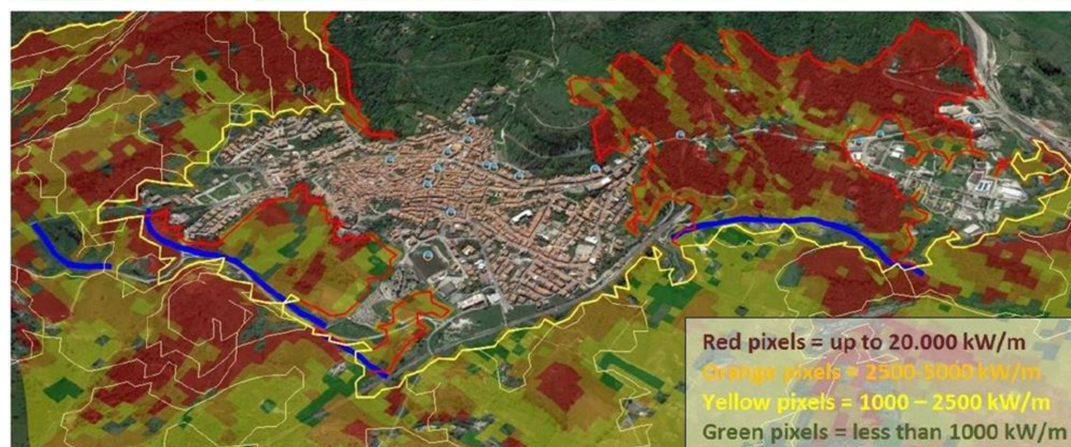
CFVA - Corpo Forestale e di V.A. della Sardegna

Consiglio Nazionale delle Ricerche
Istituto per la BioEconomia

Pilot project: Planning and testing fuel management activities to promote prevention and resilience to wildfires in the municipality of Bonorva

Goal «A» – Reducing wildfire ignitions and risk in the WUI area

Expected ROS and FLI SW winds scenario (WWS Simulator, Arca et al. 2019)



Wildfire risk management in Sardinia WUIs

Fuel Management Plans

Treatment Areas

Emergency Plans

Thank you for your attention!

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