Resilient landscapes to face catastrophic forest fires: global insights towards a new paradigm

Socioeconomic perspectives and world experiences to manage and mitigate forest fire risks

# *Wildfire Management in Catalonia:*

*A proposal towards a long-term comprehensive strategy*


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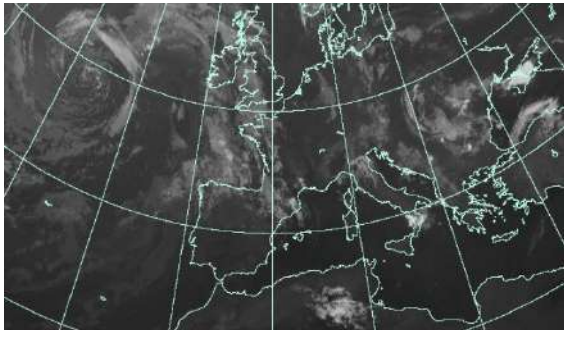
# The Mediterranean wildfire problem

In southern EU some 48.600 fires burn annually about 447.800 ha; BA is declining, extreme events are stable in number but expected to increase

Extreme events (< 5% in number) currently pose a real threat to humans, property and natural values (> 90% of burned area), with major drivers being:

- Fuel buildup in cultural landscapes
- A high incidence of human ignitions
- A widely enforced fire exclusion policy
- A growing wildland-urban interface (WUI)
- An extreme behavior resistant to suppression efforts

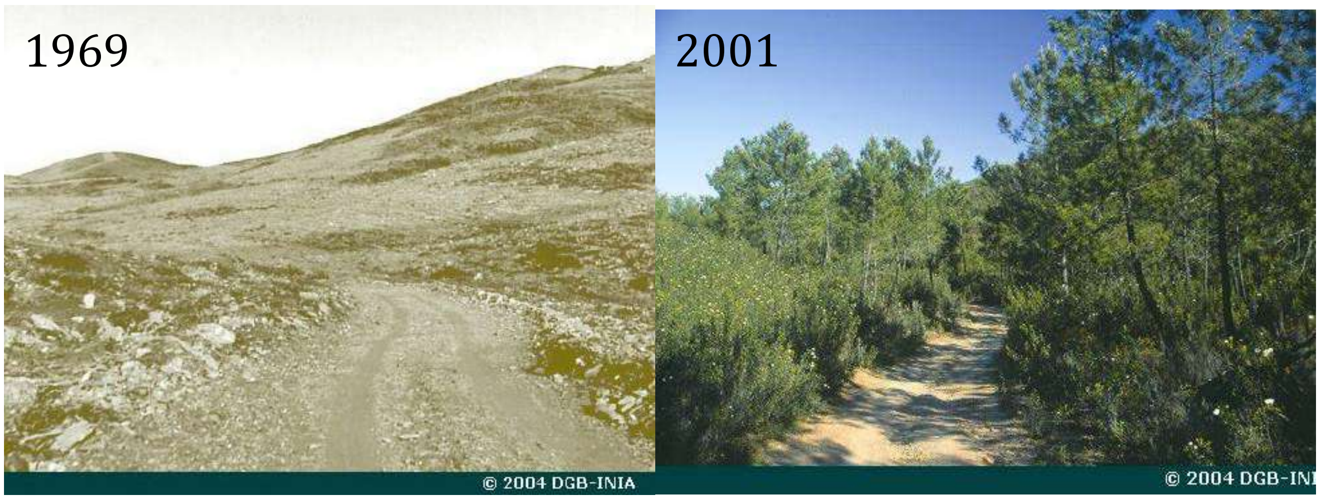


Climate uncertainty linked to dry spells, heat waves and synoptic situations: i.e. northern advection of very hot and very dry air

# A long-term solution?

We need a new long-term wildfire management comprehensive strategy to better coexist with fire, beyond suppression and ignition prevention

Aroche, Huelva




http://wwwx.inia.es/fototeca/index.jsp

Objective:*“ to provide a wildfire risk management-oriented framework for Mediterranean multi-functional cultural landscapes while developing a cross-scale fuels reduction strategy to mitigate the negative impacts from large wildfire events and better coexist with fire”*

# A long-term solution

We present a general framework for a wildfire management comprehensive strategy proposed for the southern European fire-prone regions:

We identified four major objectives and the corresponding most feasible management options

Wildfire occurrence, hazard, exposure, and large fire transmission metrics were used to rank priorities in the different management options

To illustrate the potential applicability of the framework we present some examples for its implementation in Catalonia (northeastern Spain) at the municipality level


Journal of Environmental Management

Towards a comprehensive wildfire management strategy for Mediterranean areas: Framework development and implementation in Catalonia, Spain

Fermín J. Alcasena, Alan A. Ager, John D. Bailey, Nicolau Pineda, Cristina Vega-García

Alcasena et al. 2019

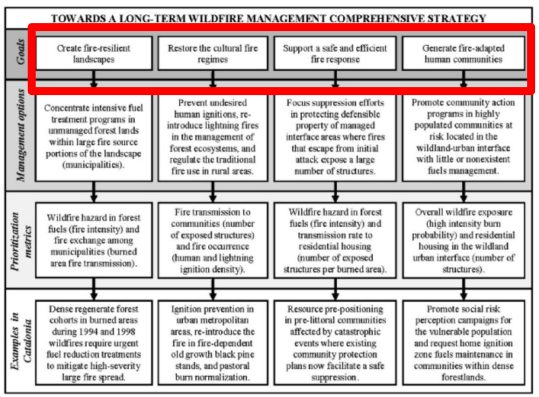
# A significant difference with the National Cohesive Strategy- USFS 2015

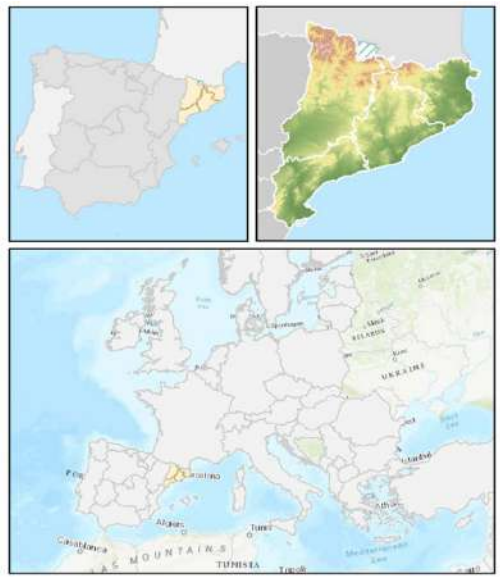
**TOWARDS A LONG-TERM WILDFIRE MANAGEMENT COMPREHENSIVE STRATEGY**

| | | | | |
|---|---|---|---|---|
| *Goals* | Create fire-resilient landscapes | Restore the cultural fire regimes | Support a safe and efficient fire response | Generate fire-adapted human communities |
| *Management options* | Concentrate intensive fuel treatment programs in unmanaged forest lands within large fire source portions of the landscape (municipalities). | Prevent undesired human ignitions, re-introduce lightning fires in the management of forest ecosystems, and regulate the traditional fire use in rural areas. | Focus suppression efforts in protecting defensible property of managed interface areas where fires that escape from initial attack expose a large number of structures. | Promote community action programs in highly populated communities at risk located in the wildland-urban interface with little or nonexistent fuels management. |
| *Prioritization metrics* | Wildfire hazard in forest fuels (fire intensity) and fire exchange among municipalities (burned area fire transmission). | Fire transmission to communities (number of exposed structures) and fire occurrence (human and lightning ignition density). | Wildfire hazard in forest fuels (fire intensity) and transmission rate to residential housing (number of exposed structures per burned area). | Overall wildfire exposure (high intensity burn probability) and residential housing in the wildland urban interface (number of structures). |
| *Examples in Catalonia* | Dense regenerate forest cohorts in burned areas during 1994 and 1998 wildfires require urgent fuel reduction treatments to mitigate high-severity large fire spread. | Ignition prevention in urban metropolitan areas, re-introduce the fire in fire-dependent old growth black pine stands, and pastoral burn normalization. | Resource pre-positioning in pre-littoral communities affected by catastrophic events where existing community protection plans now facilitate a safe suppression. | Promote social risk perception campaigns for the vulnerable population and request home ignition zone fuels maintenance in communities within dense forestlands. |

USDA Forest Service, 2014. The National Strategy: The final phase in the development of the National Cohesive Wildland Fire Management Strategy. 93.

We combine historical ignition data, outputs from simulation modeling, land use patterns and valued assets to map these specific fire and fuel management goals in Catalonia, NE Spain



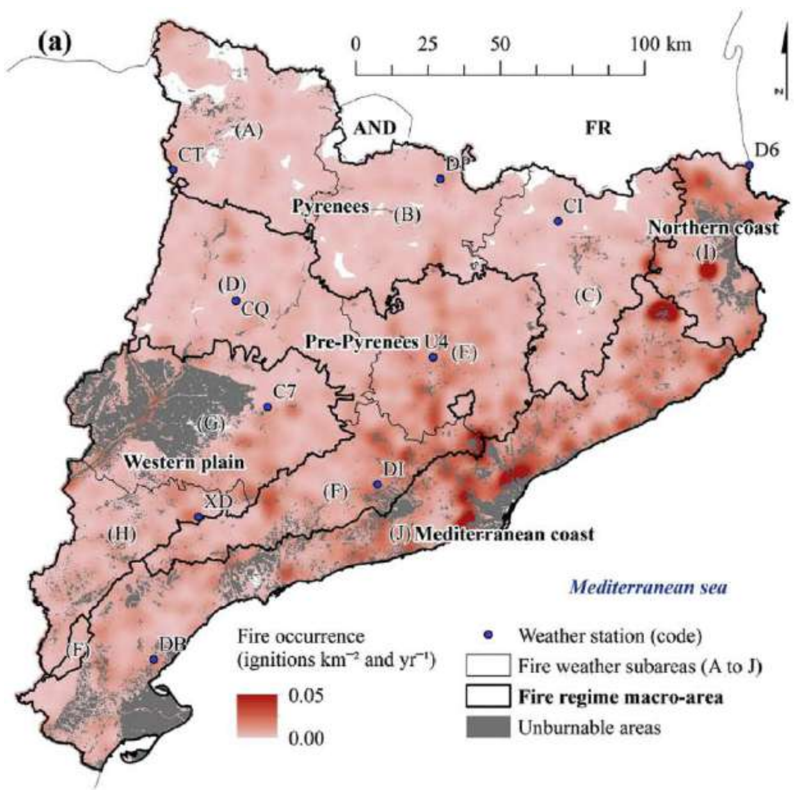
Catalonia is one of the largest fire-prone areas in the Mediterranean basin and encompasses a wide variety of landscapes, fuel types, WUI, physiographic gradients, climates, and fire ignition patterns

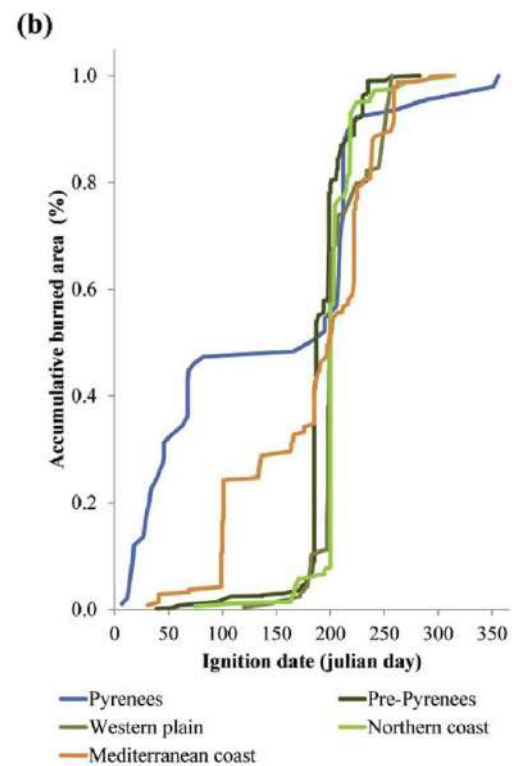
Approx. 2 mill ha forests

On average some 650 fires burn about 11.5 thousand ha yr−1
A low number (< 2%) of large fires (> 100 ha) account for 88% of the BA
A few extreme events (> 1.000 ha fire of 1986, 1994, 1998, 2003 and 2012) concentrate the bulk (> 65%) of the burned area.
Most fire ignitions (> 90%) are caused by humans (1983–2014)

Spatial extent (a) and historic fire activity (b) for the major fire regime macro-areas in Catalonia: Regime Regions

A fire occurrence grid (a) was generated with kernel geostatistical methods using historical ignition locations (human and lightning) from 1998 to 2014. The fire regime macro-areas were further divided into 10 fire-weather subareas to consider the changing conditions on local wind scenarios



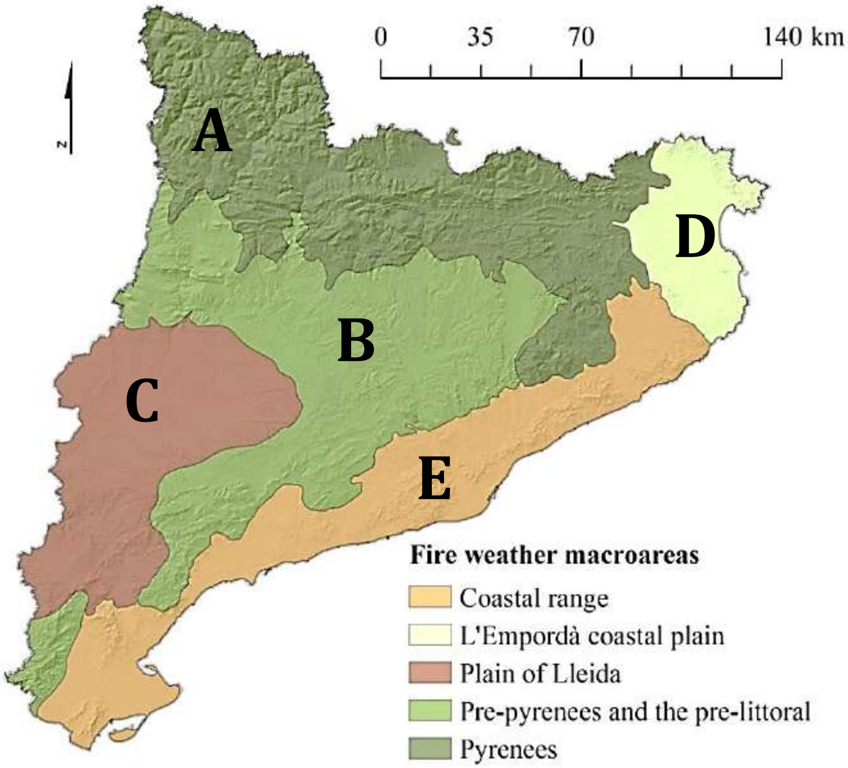



# Fire historical data:

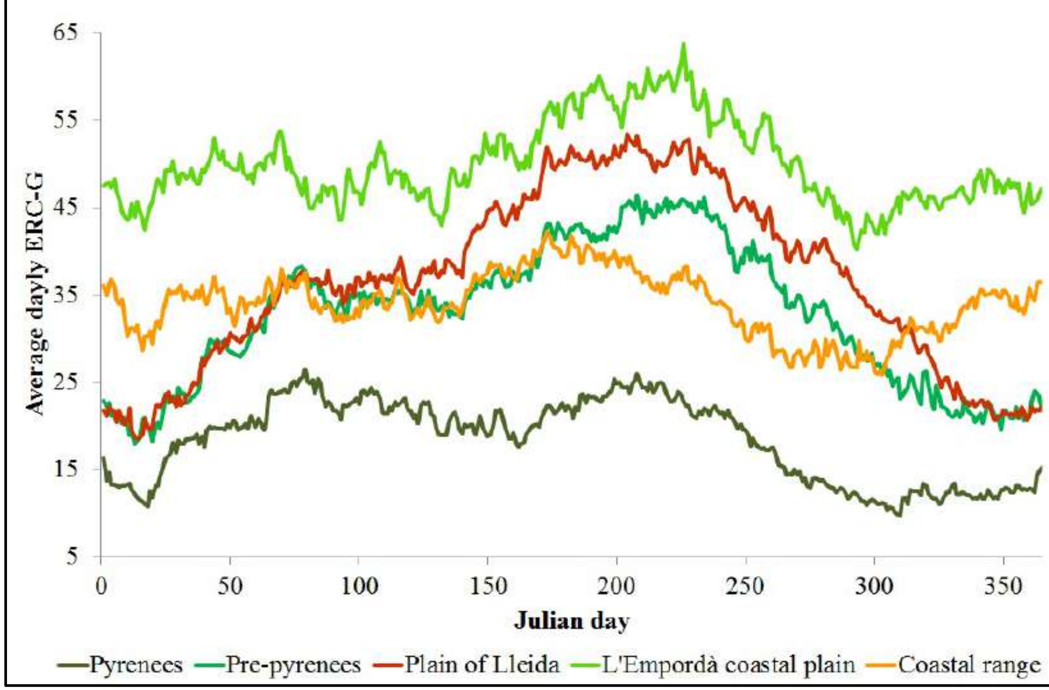
Used to determine the wildfire season duration (90% BA in fires > 100ha) for extreme fire-weather scenarios (97th percentile winds and fuel moisture content), from automatic weather station data

Wildfire history on the main fire regime macro-areas of Catalonia (northeastern Spain; Fig. 2a). We considered a 100 ha large fire threshold to calculate the large fire frequency and define the wildfire season from the historical fire activity chart (Fig. 2b). The mean annual burn probability in Catalonia is 0.0036.

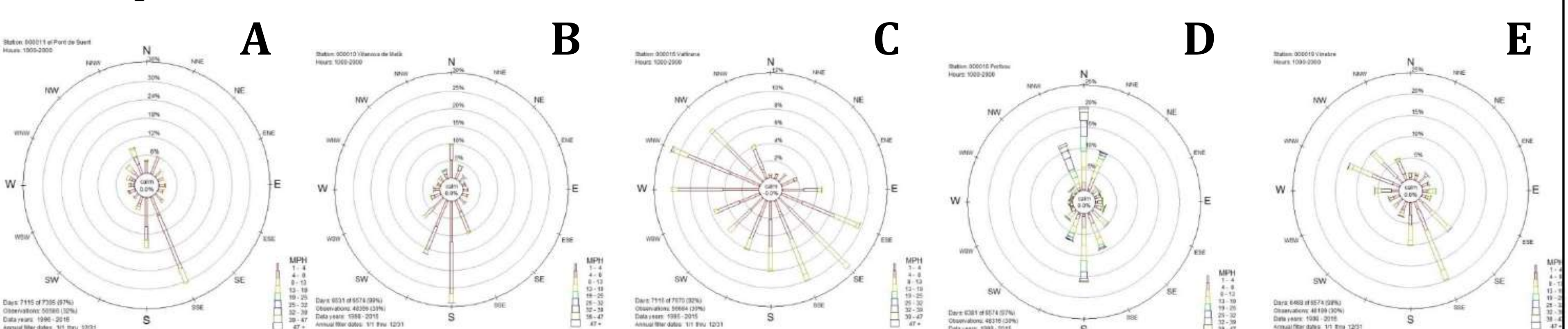
| Fire regime macro-area | Wildfire season | Area (ha) | Large fire number (per $10^6$ ha and $yr^{-1}$) | Burned area (ha $yr^{-1}$) | Mean annual burn probability |
|---|---|---|---|---|---|
| Pyrenees | Jan 7 to March 9, and July 13 to October 12 | 881,035 | 1.5 | 488 | 0.0006 |
| Pre-Pyrenees | Jun 26 to August 27 | 837,776 | 5.1 | 5,234 | 0.0062 |
| Western plain | July 10 to September 13 | 418,626 | 2.8 | 1,261 | 0.0030 |
| Northern coast | Jun 18 to August 11 | 157,226 | 7.8 | 1,911 | 0.0122 |
| Mediterranean coast | April 8 to September 10 | 531,950 | 5.6 | 2,604 | 0.0049 |




## Fuel moisture




## Wind speed and direction



## Fire historical data + fire spread modeling:

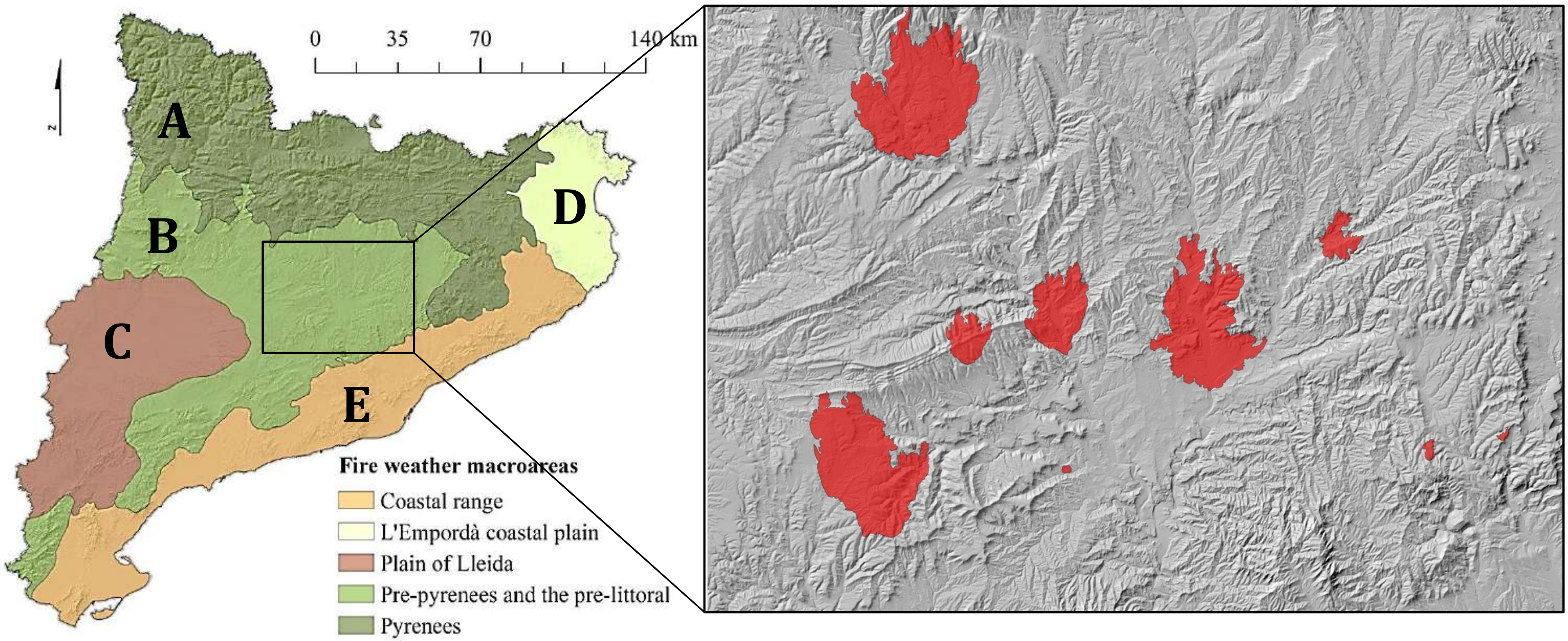
We used large fire size distributions for calibration of the fire spread model (160,000 fires >100 ha, burning BA in 10,000 fire seasons)

We used the FConstMTT command line version of FlamMap to model wildfire spread and behavior with the MTT algorithm*.  Fire modeling outputs for Catalonia at 150 m resolution: burn probability, fire intensity-flame length probability, fire size, flow paths, crown fire activity, fire perimeters...

## Fire historical data + fire spread modeling + valued assets:

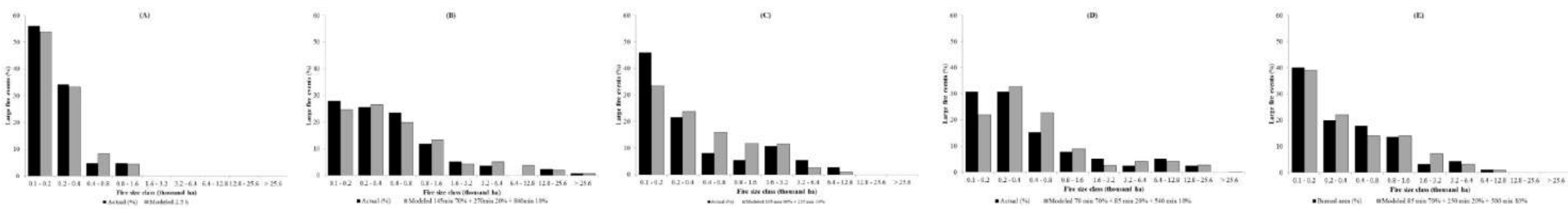
Fire modeling outputs plus valued assets geolocations allowed assessment of wildfire <u>hazard</u> (conditional flame length), overall <u>exposure</u> (high-intensity burn probability) and large fire <u>transmission</u> (flow paths and perimeters from ignition location to township or structures)

** Finney, M.A., 2006. An overview of FlamMap fire modeling capabilities. In: Andrews, P.L., Butler, B.W. (Eds.), Fuels Management-how to Measure Success. Proceedings RMRS-p-41. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO, pp. 213–220.*

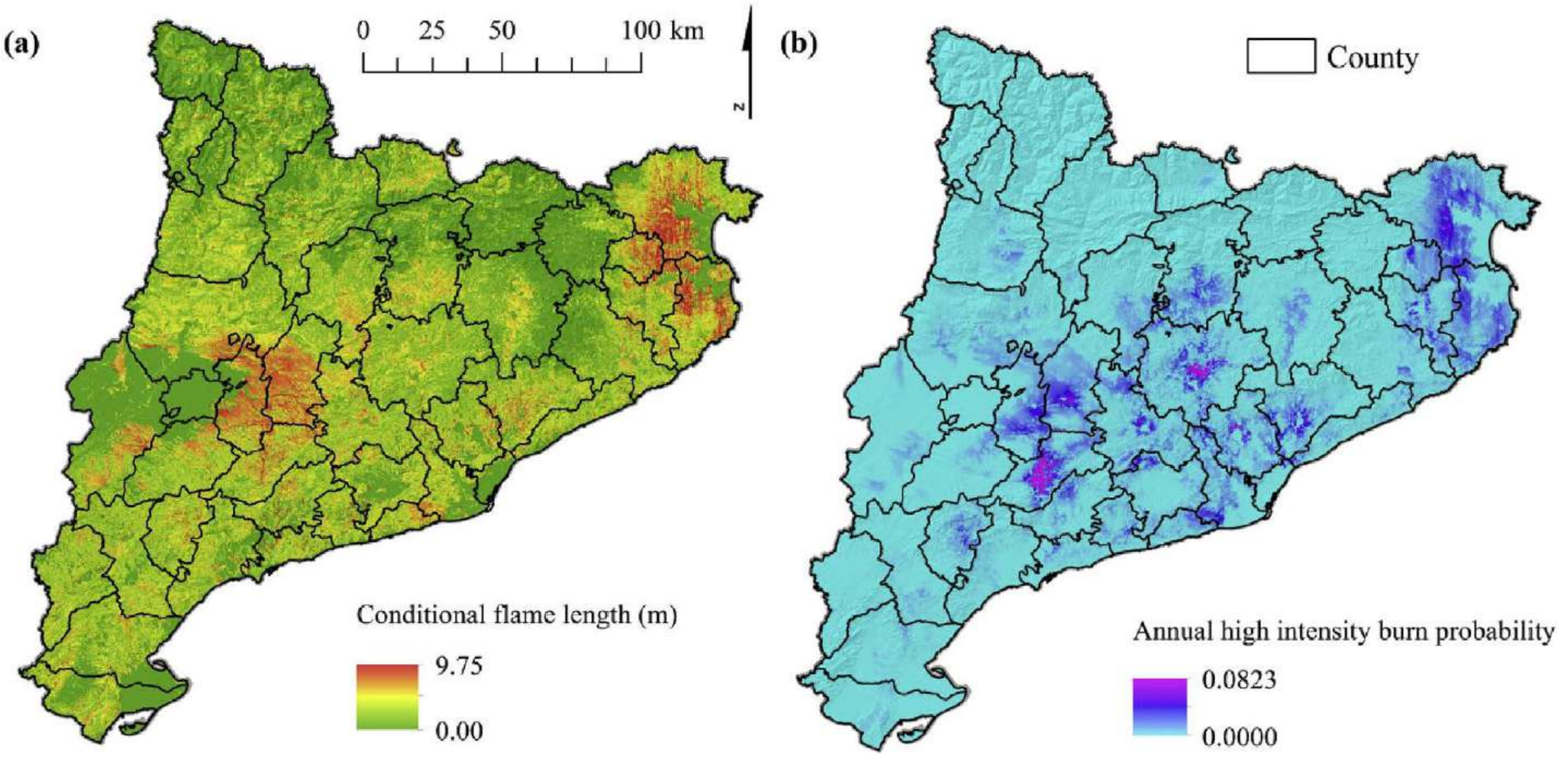



Replicate historic fire size distributions in the different macro-areas

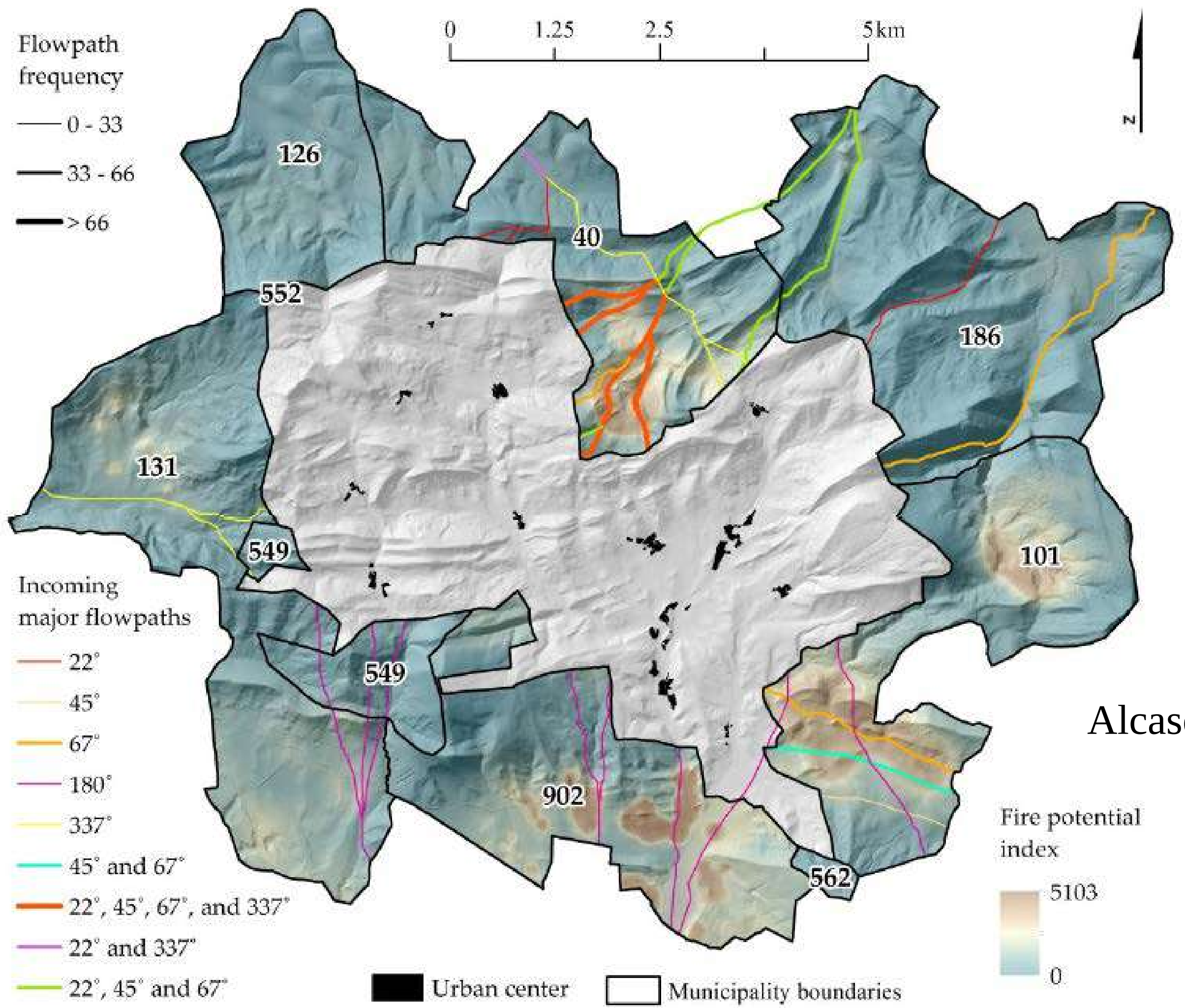
**A** **B** **C** **D** **E**



# Fire modeling outputs for Catalonia



# Flow paths converging in a township



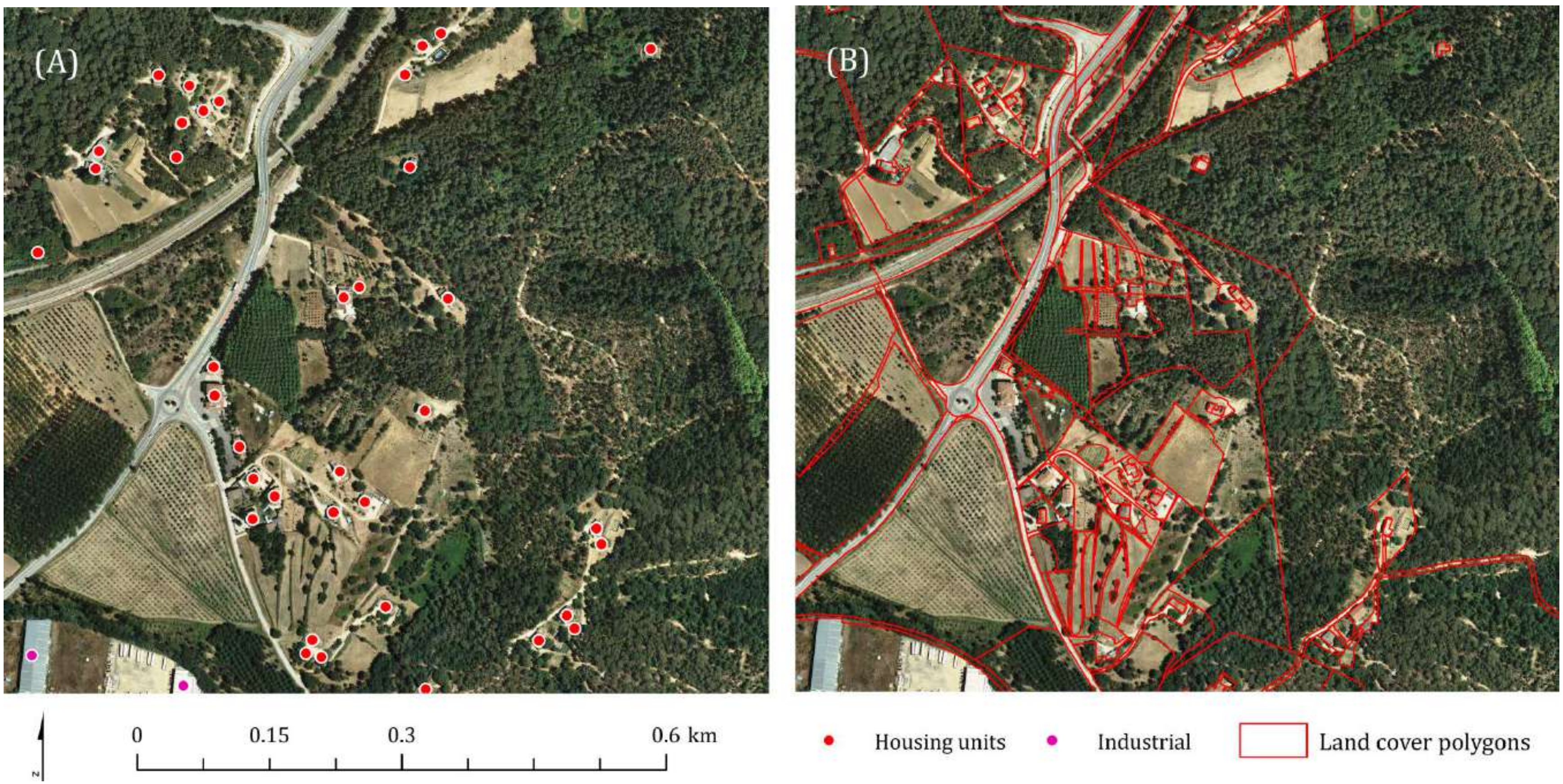

Alcasena et al. 2019

**Figure 5.** Fire potential index (FPI) and incoming major flow-paths from the surrounding municipalities. FPI was calculated by combining the fire size and ignition probability output grids, and was used to identify the areas where the ignition of a large fire is more likely [31]. Major flow-paths were obtained with the minimum travel time algorithm (MTT) [62] considering the five most recurrent fire weather scenarios (Table 2). The flow-path thickness indicates frequency and color indicates fire scenarios.

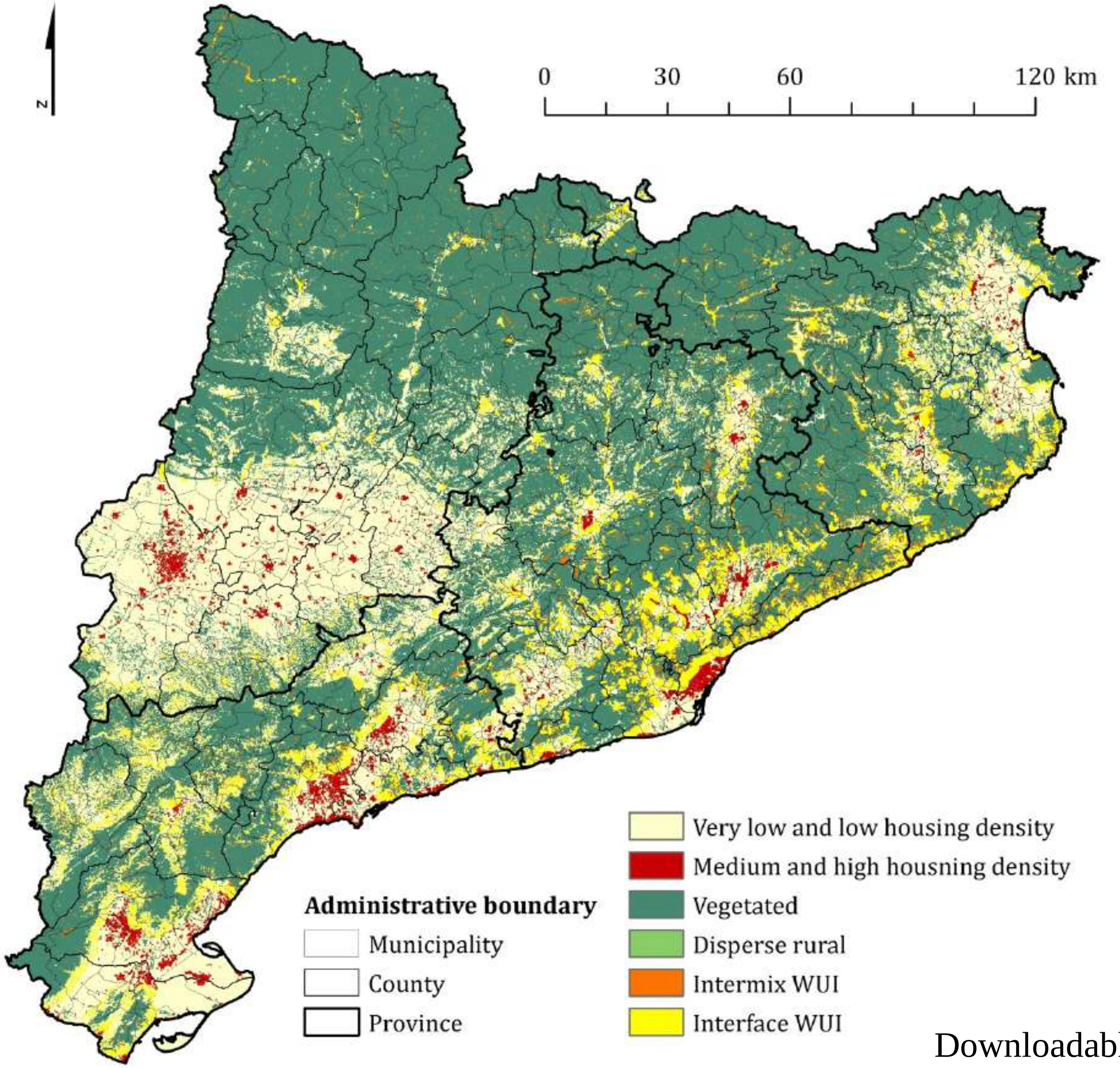
# Fire historical data + fire spread modeling + valued assets + land cover

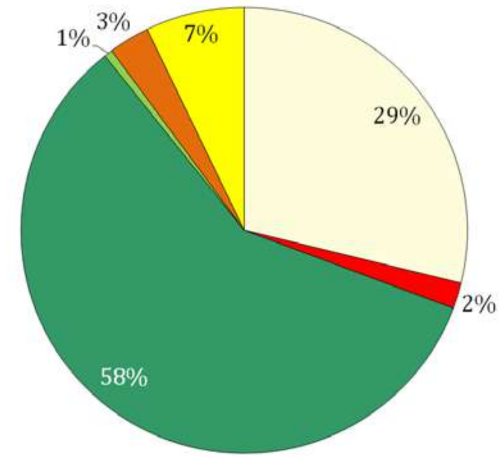
Housing structure density

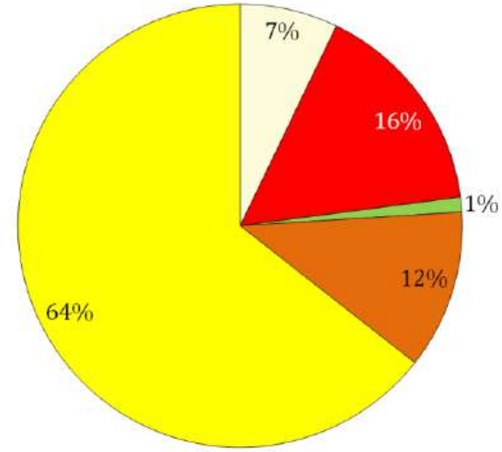
Fuel types on the HIZ (lidar)



# Wildland-Urban Interface in Catalonia

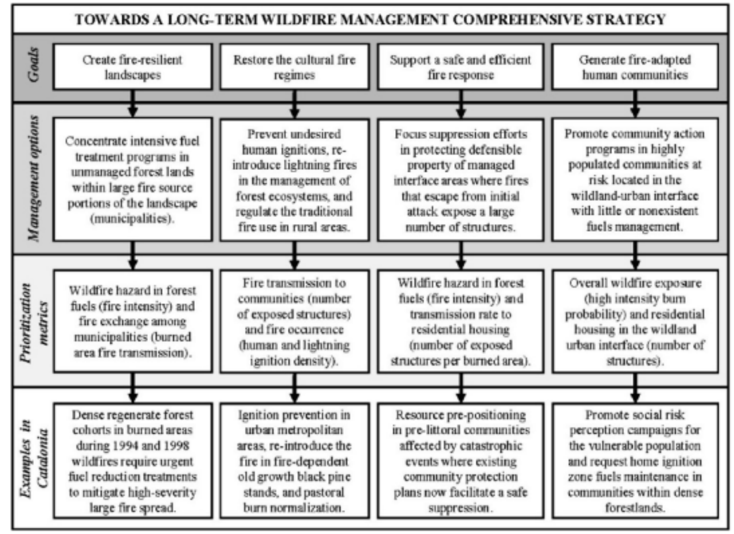



Downloadable: Alcasena et al (2018)

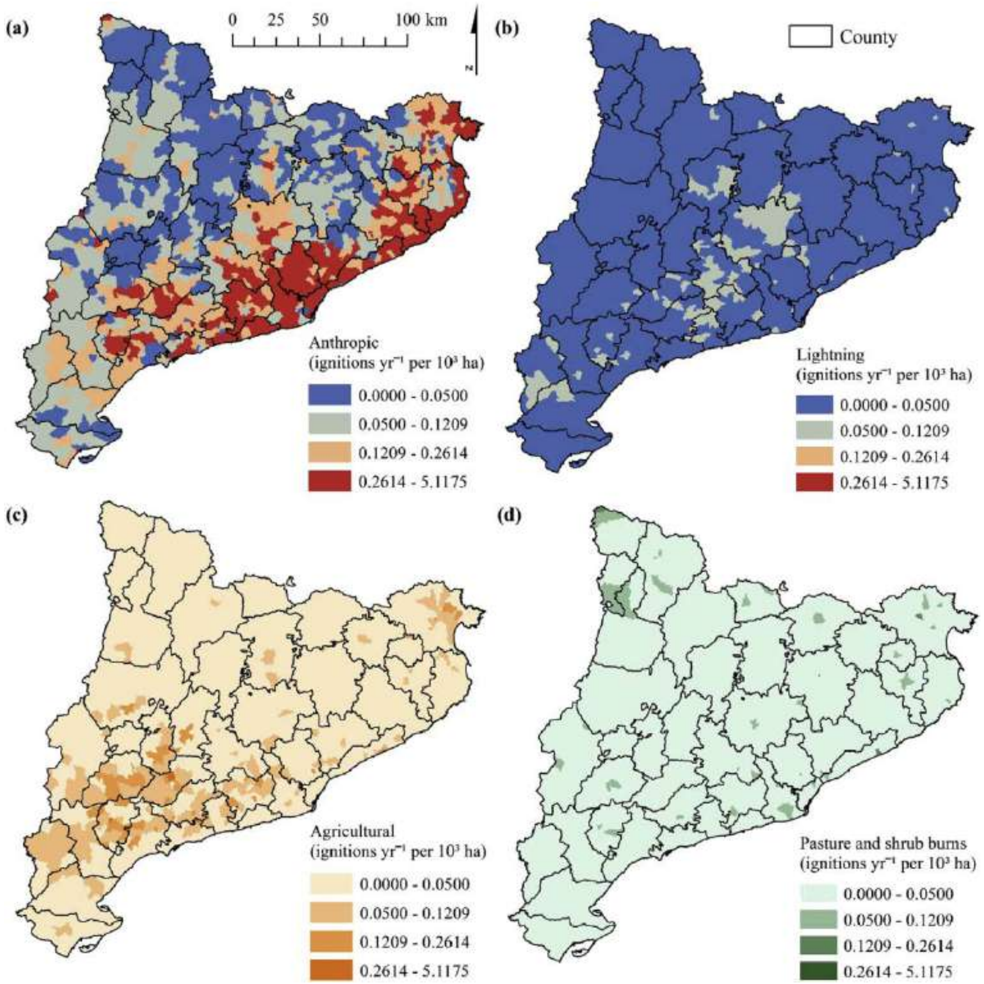
Fire historical data + fire spread modeling + valued assets + land cover = metrics = Priority Maps




Assignment of metric pairs (i.e, fire occurrence, hazard, exposure, and transmission results) to the different objectives of the wildfire management strategy (Fig. 1). These metrics were cross-tabulated to obtain 4 priority classes (Table 2). The final results were presented at the municipality level (n = 948) in a set of spatial priority maps.

| Goal | Management options | Prioritization metrics | Priority map |
|---|---|---|---|
| Create fire resilient landscapes | Fuel treatments | We used fire transmission (T_OUT quartiles; Fig. 5a) and wildfire hazard (CFL levels; Fig. 4a) to assess the priority classes. The classes were ranked from the highest transmission and hazard values to the lowest. Protected areas (Appendix B) were overlaid on the map to delineate areas with potential treatment constraints. | Fig. 7 |
| Restore the cultural fire regime | Human ignition prevention | Annual anthropic fire ignition density (ANT quartiles; Fig. 3a) and transmission to residential houses (T_RES quartiles; Fig. 6a) were used to assess the priority classes. The classes were ranked from the highest ignition density and transmission to the lowest. | Fig. 8 |
| | Natural fire re-introduction | Lightning ignition density (NAT quartiles; Fig. 5b) and transmission to residential houses (T_RES quartiles; Fig. 6a) were used to assess the classes. The classes were ranked from the highest lightning fire ignition densities to the lowest and from the lowest transmission values to the highest. | Fig. 9 |
| Support a safe and efficient response | Fire suppression | Fire transmission rates to residential houses (TR_RES; Fig. 6c) and wildfire hazard (CFL levels; Fig. 4a) was used to set the classes. The classes were ranked from the highest transmission rates to the lowest and from the lowest hazard levels to the highest. | Fig. 10 |
| Generate fire-adapted communities | Community action | High overall exposure levels (annual HIBP quartiles; Fig. 4b) and number of residential houses on the wildland-urban interface (Alcasena et al., 2018a) were used to set the classes. The classes were ranked from the highest exposure values and the highest number of structures to the lowest. | Fig. 11 |

# Wildfire Management Metrics

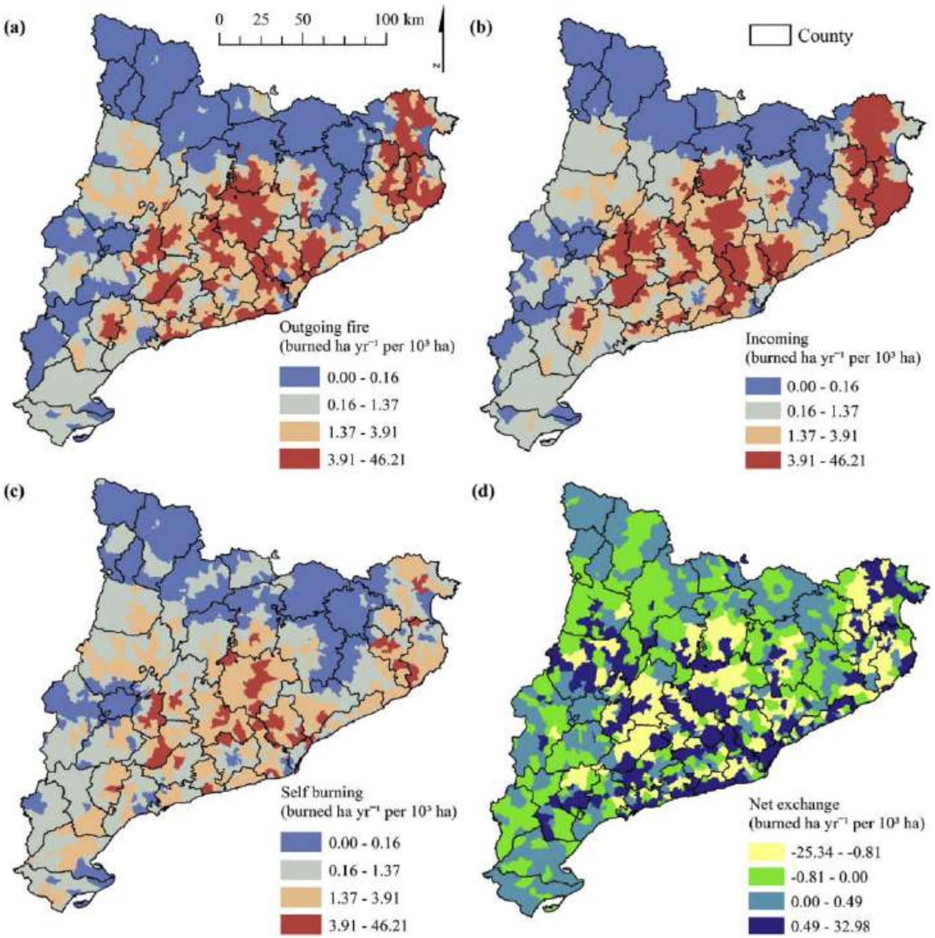



## Management options:

Human ignition prevention
Natural fire reintroduction

Municipality level anthropic (a) and lightning (a) fire ignition densities in Catalonia for the period 1983–2014. The boundaries delineate the County level administrative division. We considered the anthropic ignition density quartile value intervals to set the classes. The cultural fire use is mainly associated to agricultural waste and edge cleaning (c), and pasture or shrub clearing (d).

# Wildfire Management Metrics

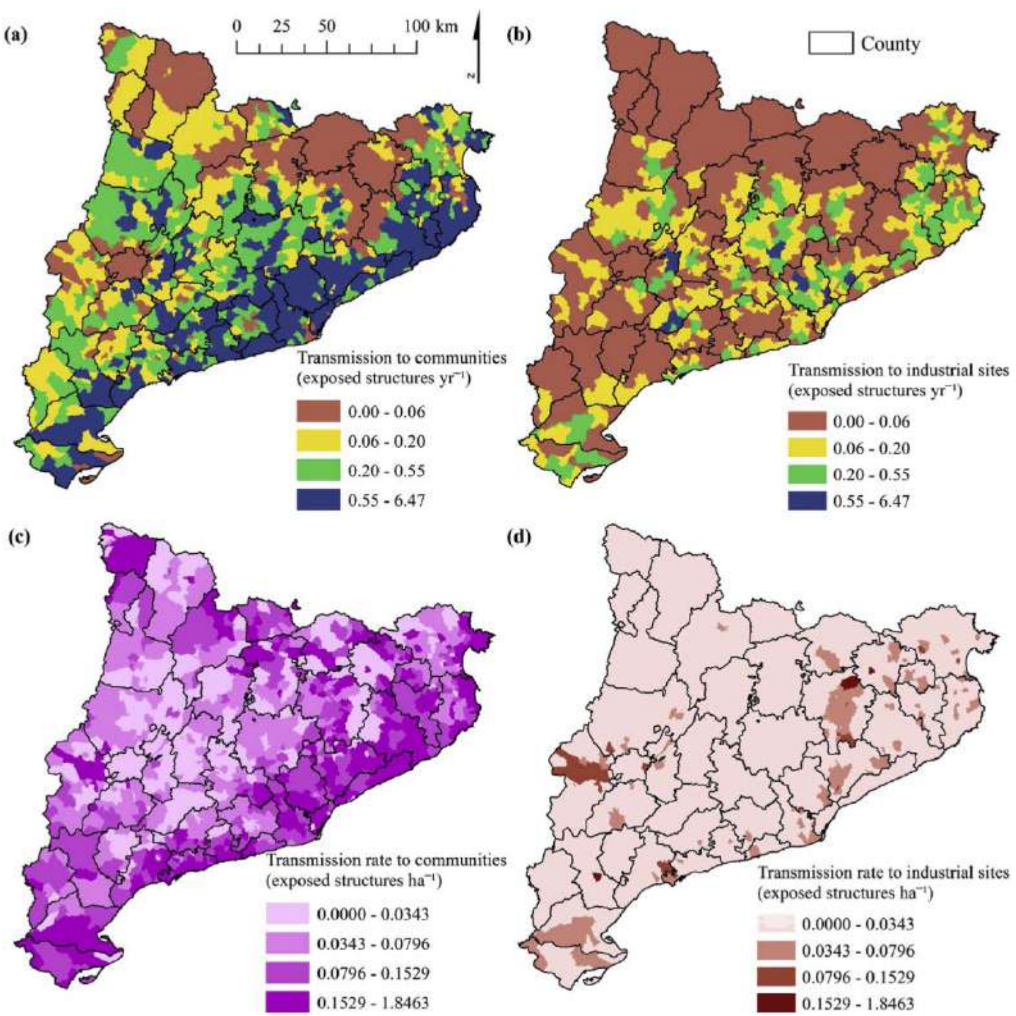



## Management options:

Human ignition prevention
Fuel treatment
Fire suppression

Fire exchange across Catalonia at the municipality level (n=948) in terms of incoming (T_IN; a), outgoing (T_OUT; b), self-burning (SB; b) and net exchange
(Net exchange=T_OUT – T_IN; d) in terms of burned ha yr−1 per a normalized municipality area of 103 ha. On average wildfires in Catalonia burn about 11.5
thousand ha yr−1 (n=650 fires yr−1; 1983 to 2014), from which the 37% of the burned area came from fires initiated on the neighboring municipalities
(ΣT_IN=ΣT_OUT=~1.5×ΣSB).

# Wildfire Management Metrics



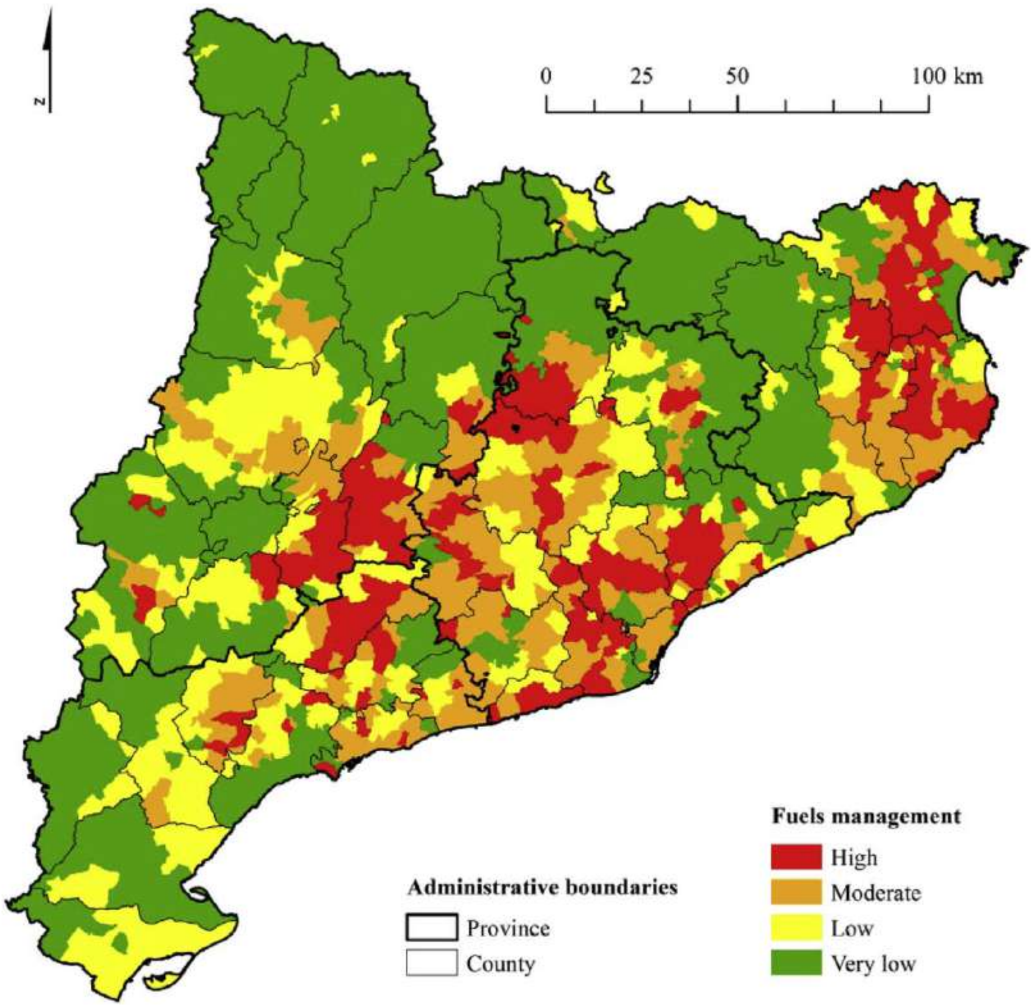

## Management options:

Human ignition prevention
Fuel treatment
Fire suppression

Annual fire transmission and transmission rate per burned area (ha) for structures in communities (a and c) and industrial sites (b and d) at the municipality level. The analysis was conducted intersecting modeling output large fire perimeters (> 100 ha) with structure centroid locations

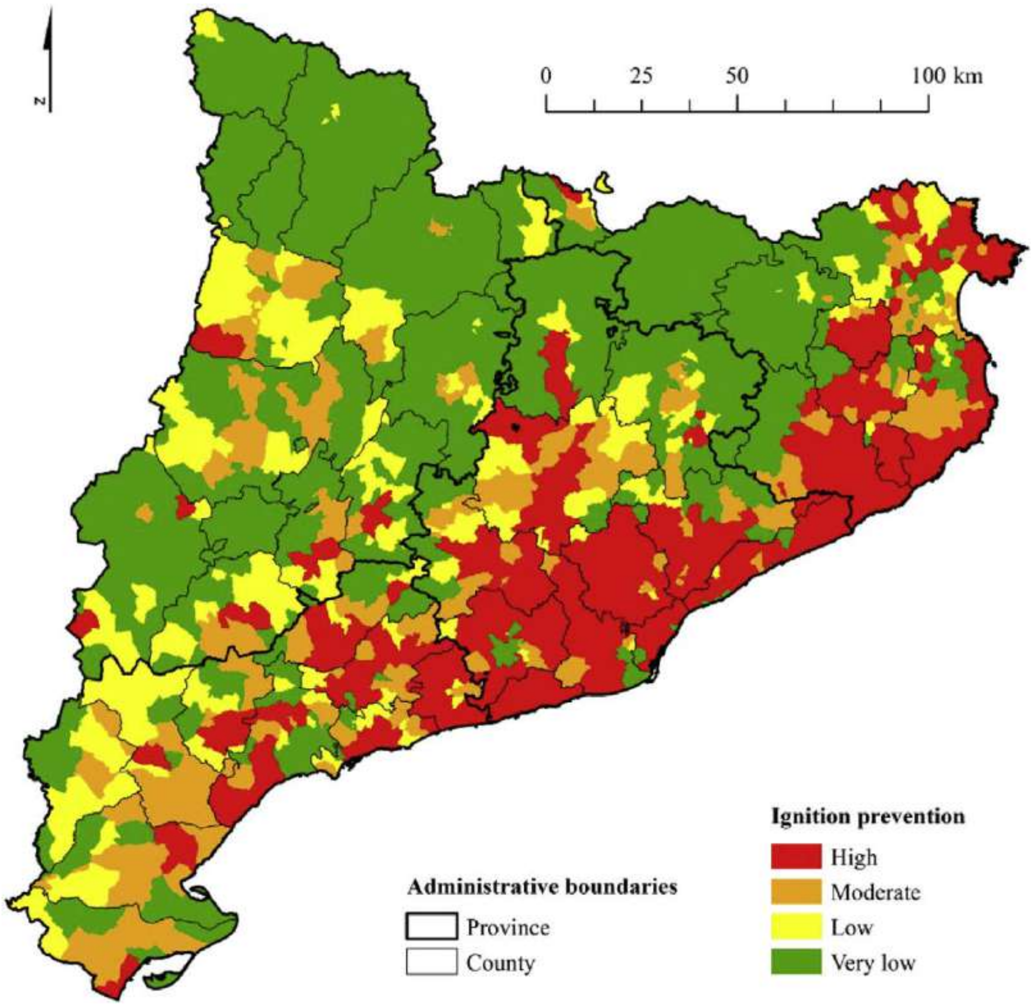
# Wildfire Management Priority maps

Spatial prioritization for fuel reduction programs in Catalonia, from cross-tabulated wildfire hazard on forest fuels (CFL levels) and burned area transmission (outgoing). The highest priorities are located on central and northeastern portions of Catalonia



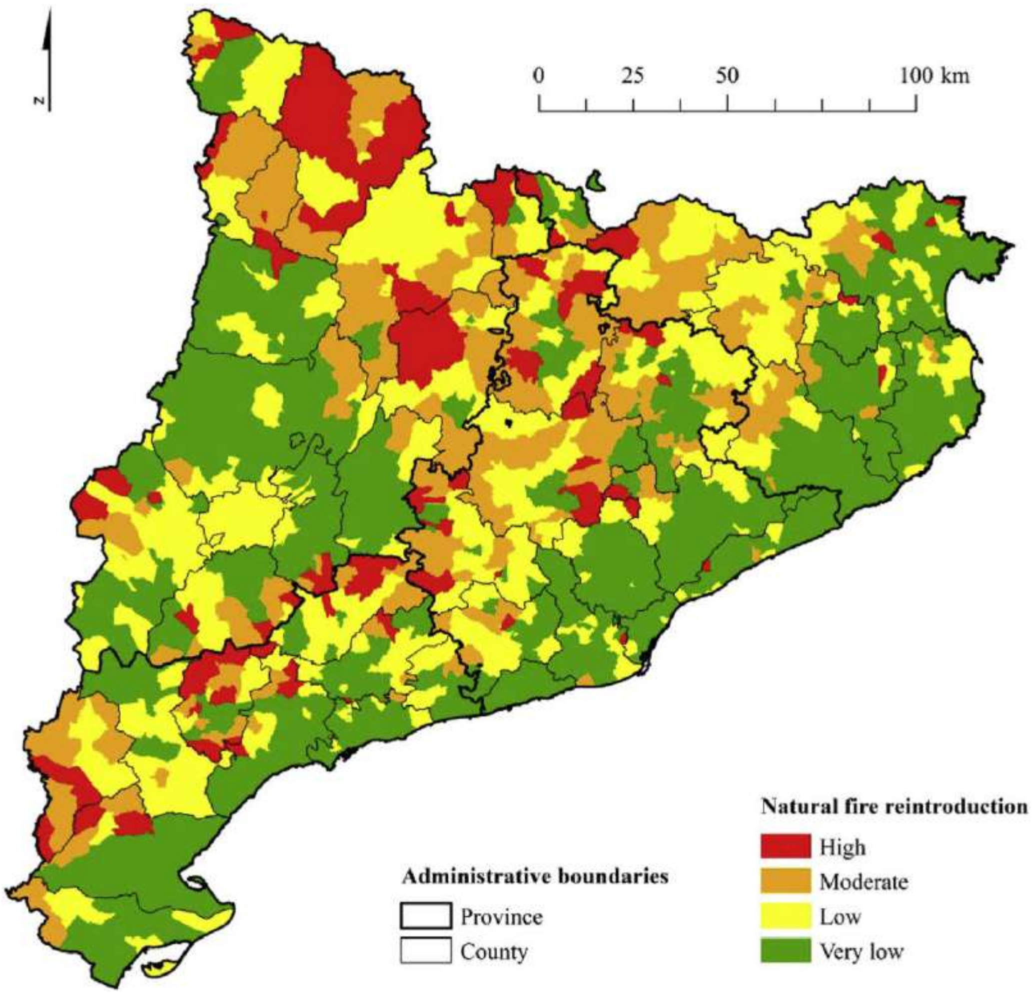
# Wildfire Management Priority maps

Spatial prioritization for <u>human ignition prevention</u> in Catalonia. From cross tabulated anthropic fire ignition densities and transmission to residential houses. Coastal and metropolitan areas of Barcelona showed the highest priority



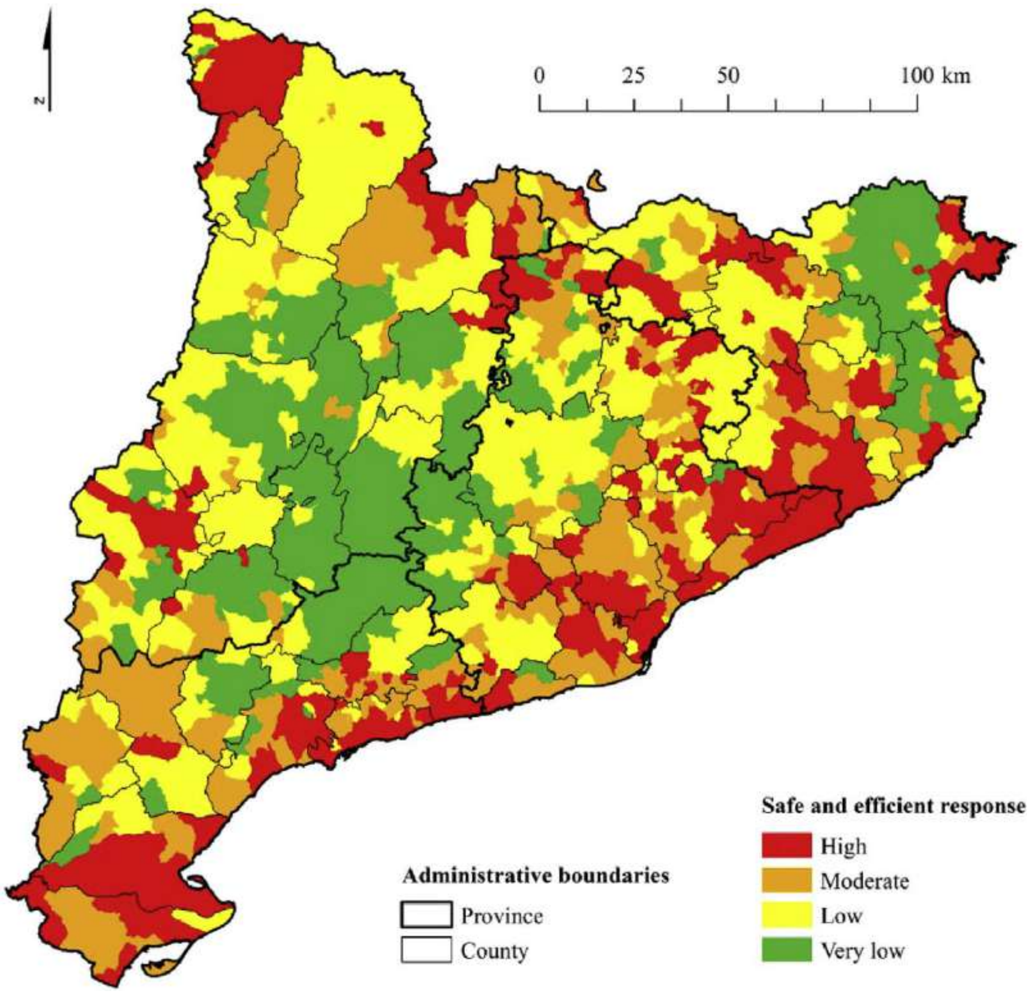
# Wildfire Management Priority maps

Spatial prioritization for <u>natural fire reintroduction</u> in forest ecosystems from cross tabulated lightning fire ignition densities and transmission to residential houses. The municipalities with a highest potential located on remote mountainous areas were lightning fire reintroduction would not pose a risk to communities



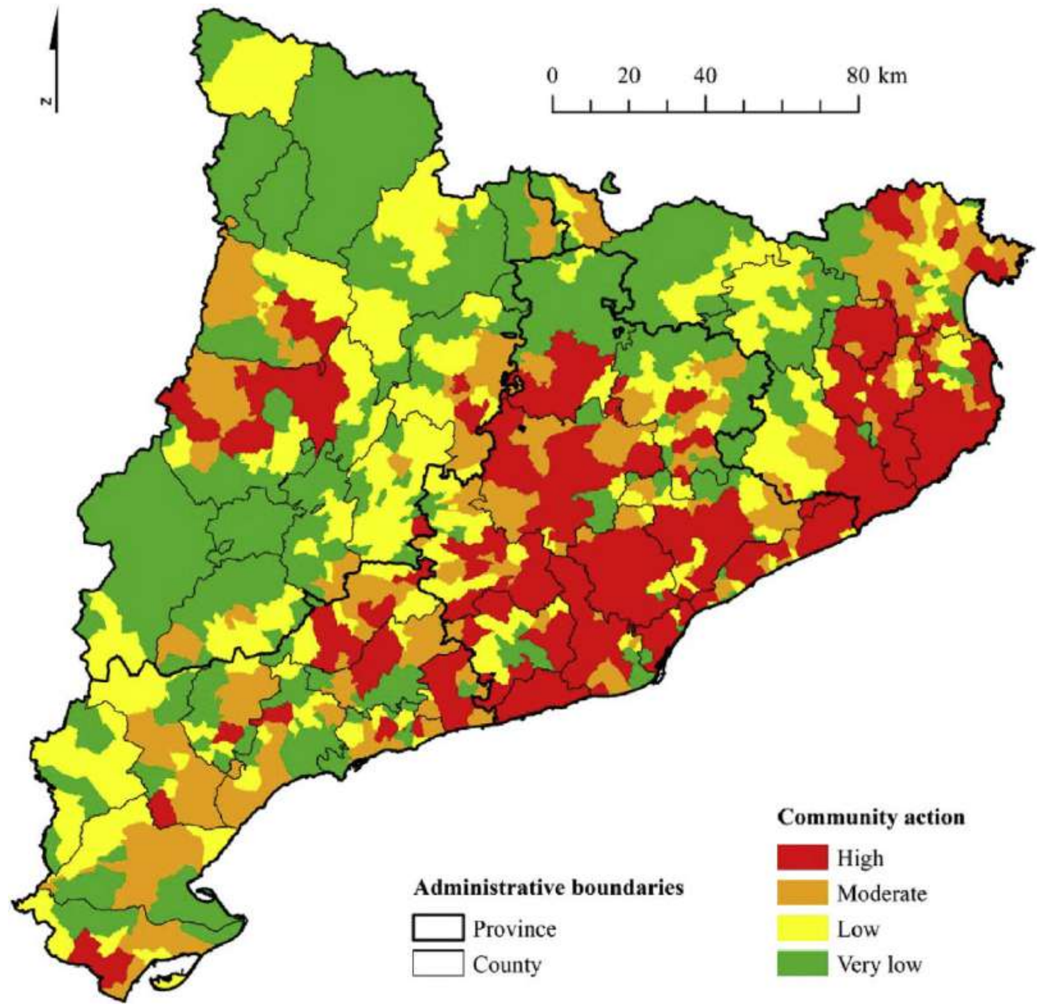
# Wildfire Management Priority maps

Spatial prioritization for a <u>safe and efficient response</u> in Catalonia from cross-tabulated wildfire hazard (CFL levels) and transmission rate to communities, candidates for an aggressive full suppression policy. Wildland-urban interface areas surrounded by managed fuels, predominantly agricultural plains and narrow valleys of the Pyrenees presented the highest priority



# Wildfire Management Priority maps

Spatial prioritization for <u>community action</u> program implementation in Catalonia from cross-tabulated wildfire exposure values on the home ignition zone (annual HIBP quartiles) and the number dwellings on the WUI. The top priorities are located on populated littoral and pre-littoral areas of Barcelona and Girona



# So once we have these priorities, how to implement management action?

**TOWARDS A LONG-TERM WILDFIRE MANAGEMENT COMPREHENSIVE STRATEGY**

| | | | | |
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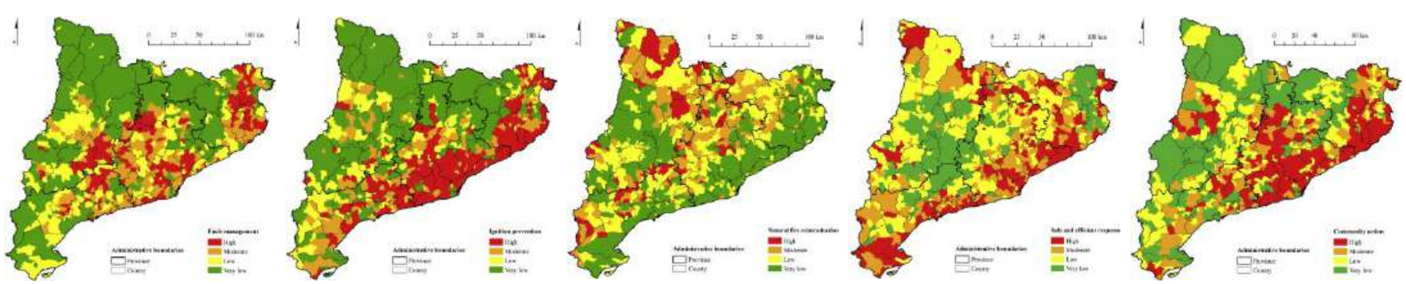
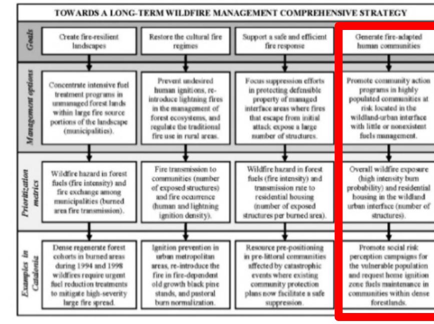


# Higher resolution is needed: Community action

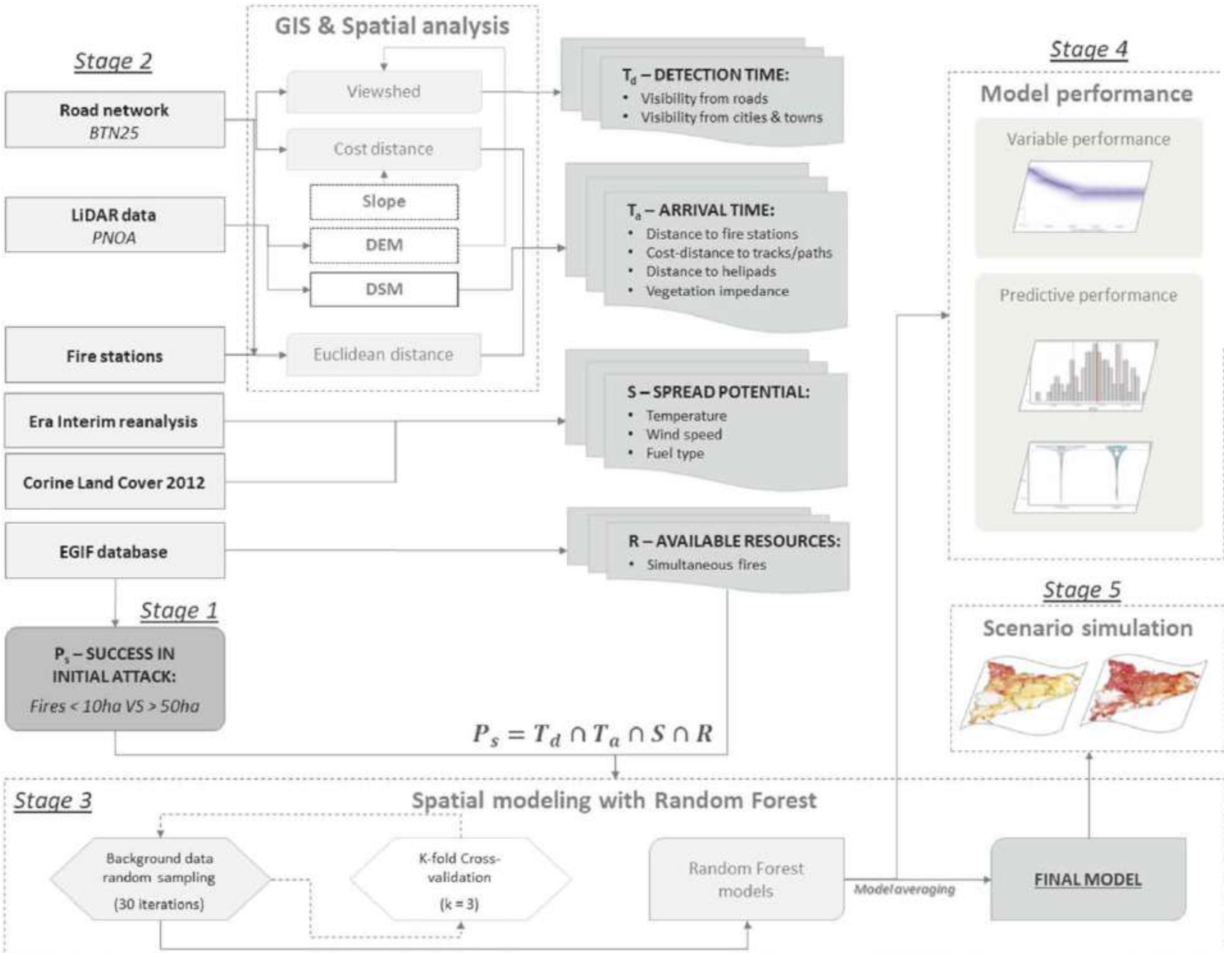


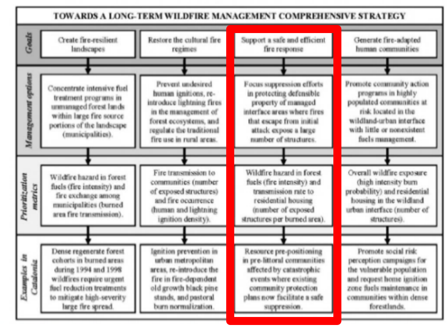

## Avg. HIBP for the top-25 municipalities in Catalonia by WUI class: structure level

| Municipality | Province | WUI class: Disperse rural structures | Disperse rural avg. aHIBP | Intermix structures | Intermix avg. aHIBP | Interface structures | Interface avg. aHIBP | Total structures | Total avg. aHIBP |
|---|---|---|---|---|---|---|---|---|---|
| Rubí | Barcelona | 1 | 0.0004 | 410 | 0.0053 | 3089 | 0.0044 | 3500 | 0.0046 |
| Lliçà d'Amunt | Barcelona | 1 | 0.0009 | 272 | 0.0040 | 2612 | 0.0055 | 2885 | 0.0051 |
| Terrasa | Barcelona | 7 | 0.0047 | 409 | 0.0090 | 2056 | 0.0113 | 2472 | 0.0106 |
| Calonge | Girona | 8 | 0.0047 | 469 | 0.0047 | 1944 | 0.0089 | 2421 | 0.0074 |
| Mançanet de la Selva | Gerona | 14 | 0.0008 | 415 | 0.0034 | 1992 | 0.0061 | 2421 | 0.0051 |
| Begur | Gerona | 4 | 0.0054 | 269 | 0.0050 | 1935 | 0.0050 | 2208 | 0.0050 |
| Girona | Gerona | 12 | 0.0081 | 322 | 0.0084 | 1833 | 0.0073 | 2167 | 0.0076 |
| Cervelló | Barcelona | 5 | 0.0031 | 170 | 0.0036 | 1957 | 0.0057 | 2132 | 0.0052 |
| Palafrugell | Gerona | 7 | 0.0068 | 261 | 0.0068 | 1855 | 0.0093 | 2123 | 0.0087 |
| Santa Cristina d'Aro | Gerona | 23 | 0.0050 | 359 | 0.0087 | 1682 | 0.0085 | 2064 | 0.0084 |
| Caldes de Montbui | Barcelona | 12 | 0.0022 | 316 | 0.0047 | 1507 | 0.0108 | 1835 | 0.0088 |
| Santa Eulàlia de Ronçana | Barcelona | 1 | 0.0047 | 158 | 0.0047 | 1653 | 0.0067 | 1812 | 0.0063 |
| Castell-Platja d'Aro | Gerona | 5 | 0.0084 | 385 | 0.0067 | 1316 | 0.0077 | 1706 | 0.0073 |
| l'Amatlla del Vallès | Barcelona | 1 | 0.0134 | 210 | 0.0055 | 1396 | 0.0065 | 1607 | 0.0062 |
| Pals | Gerona | 6 | 0.0079 | 187 | 0.0080 | 1335 | 0.0099 | 1528 | 0.0095 |
| Castellbisbal | Barcelona | 9 | 0.0029 | 172 | 0.0057 | 1335 | 0.0057 | 1516 | 0.0056 |
| Esparreguera | Barcelona | 5 | 0.0108 | 132 | 0.0081 | 1357 | 0.0071 | 1494 | 0.0075 |
| Llagostera | Gerona | 18 | 0.0028 | 194 | 0.0041 | 1280 | 0.0079 | 1492 | 0.0070 |
| Palau-solità i Plegamans | Barcelona | 0 | 0.0000 | 69 | 0.0051 | 1294 | 0.0073 | 1363 | 0.0071 |
| Vilanova del Vallès | Barcelona | 2 | 0.0065 | 208 | 0.0055 | 1067 | 0.0082 | 1277 | 0.0074 |
| Sentmenat | Barcelona | 8 | 0.0034 | 209 | 0.0036 | 984 | 0.0097 | 1201 | 0.0080 |
| Olesa de Montserrat | Barcelona | 6 | 0.0065 | 141 | 0.0065 | 1021 | 0.0072 | 1168 | 0.0070 |
| Montcada i Reixac | Barcelona | 2 | 0.0049 | 283 | 0.0071 | 878 | 0.0092 | 1163 | 0.0085 |
| Sant Vicenç dels Horts | Barcelona | 0 | 0.0000 | 194 | 0.0051 | 957 | 0.0045 | 1151 | 0.0047 |
| la Roca del Vallès | Barcelona | 7 | 0.0104 | 159 | 0.0037 | 962 | 0.0098 | 1128 | 0.0083 |

# Higher resolution is needed: Safe and efficient wildfire response

A general workflow for modeling and mapping the probability of success in initial attack in Catalonia: <u>best if we contain fires early</u>



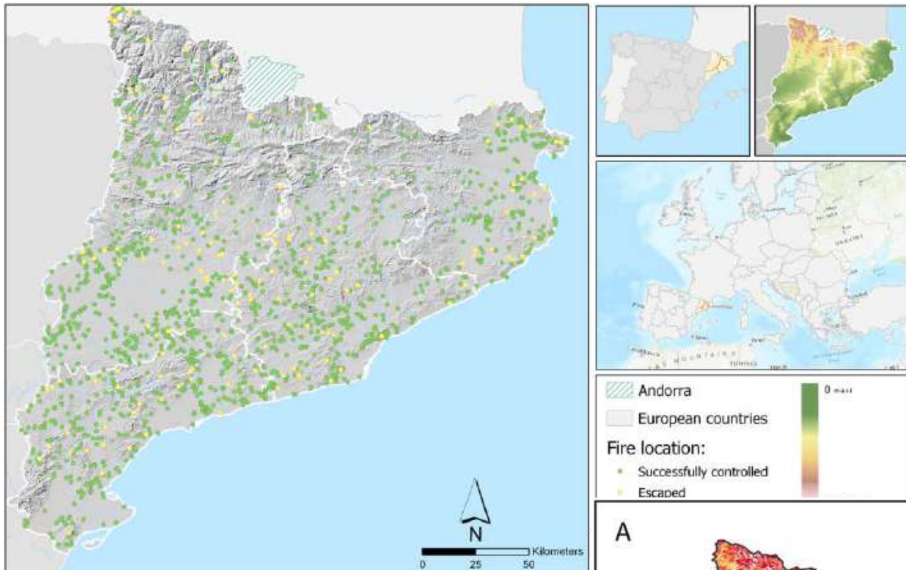





Rodrigues et al. (2019)

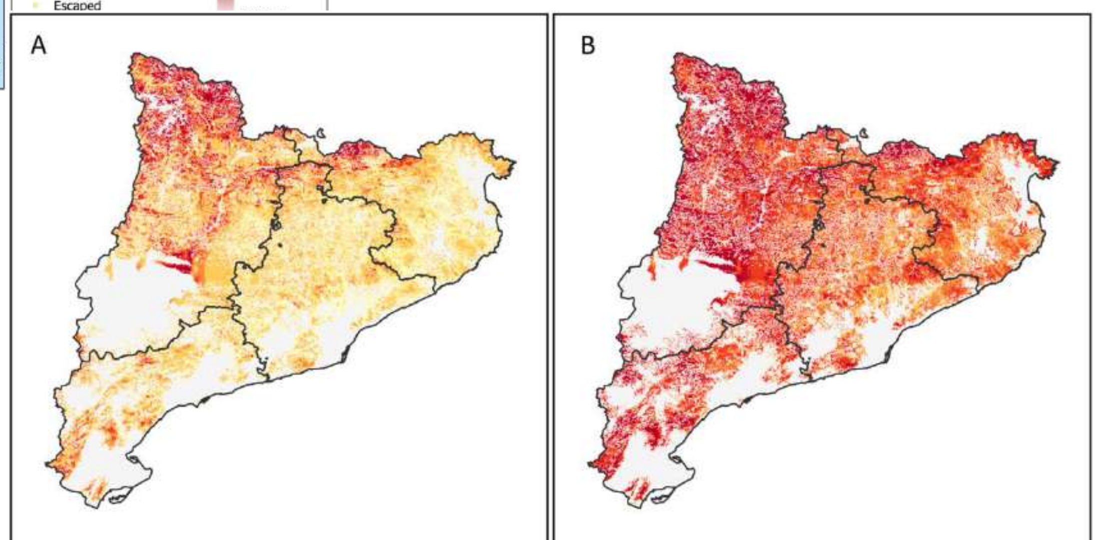
# Higher resolution is needed: Safe and efficient wildfire response

## Controlled/escaped fires at initial attack in Catalonia



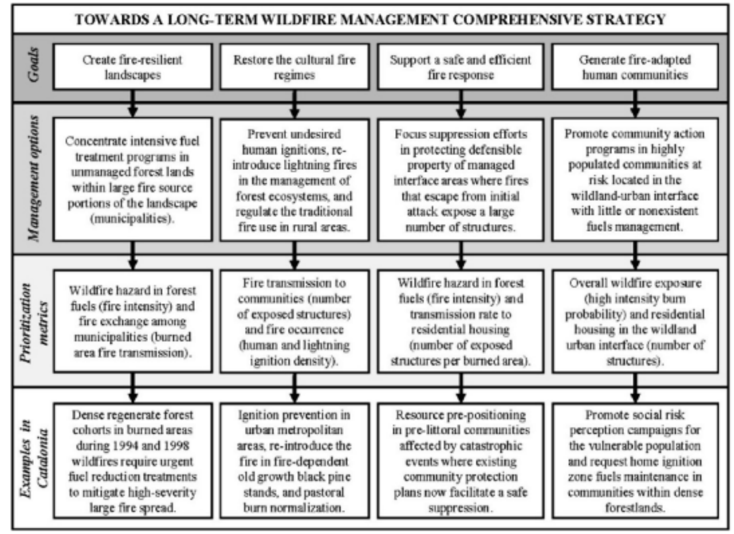

Spatial distribution of predicted probability of success (RF) in IA
A) ‘Business as usual’ scenario: temperature and wind speed at the 50th percentile, no simultaneous fires
B) ‘Worst case’ scenario, temperature and wind speed at 90th percentile, and 10 simultaneous fires

Successfully suppressed vs Escaped fires (1998–2015)

# Placing the focus back on Resilient Landscapes

Fire historical data + fire spread modeling + valued assets + land cover = Priority maps



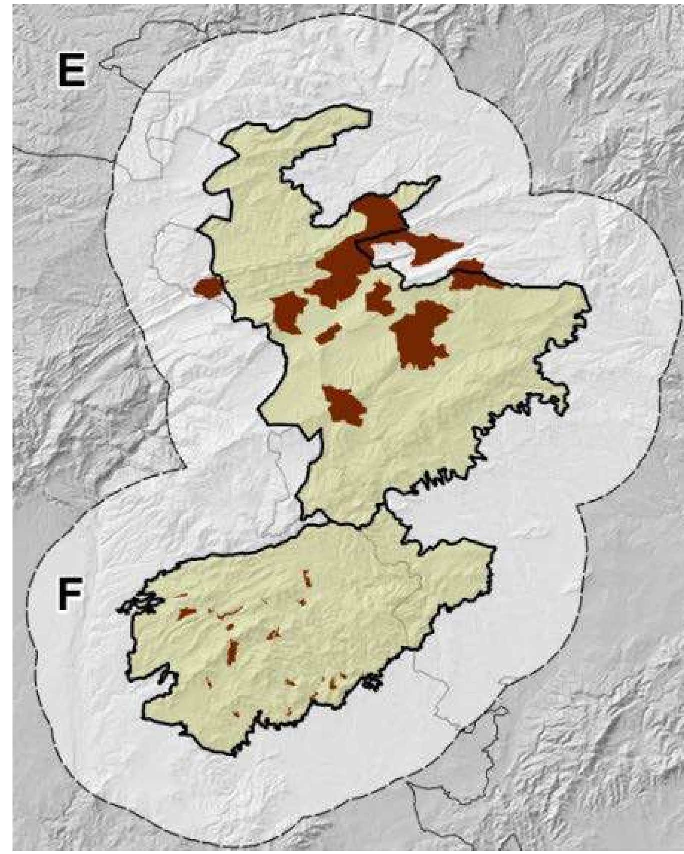

Assignment of metric pairs (i.e, fire occurrence, hazard, exposure, and transmission results) to the different objectives of the wildfire management strategy (Fig. 1). These metrics were cross-tabulated to obtain 4 priority classes (Table 2). The final results were presented at the municipality level (n = 948) in a set of spatial priority maps.

| Goal | Management options | Prioritization metrics | Priority map |
|---|---|---|---|
| Create fire resilient landscapes | Fuel treatments | We used fire transmission (T_OUT quartiles; Fig. 5a) and wildfire hazard (CFL levels; Fig. 4a) to assess the priority classes. The classes were ranked from the highest transmission and hazard values to the lowest. Protected areas (Appendix B) were overlaid on the map to delineate areas with potential treatment constraints. | Fig. 7 |
| Restore the cultural fire regime | Human ignition prevention | Annual anthropic fire ignition density (ANT quartiles; Fig. 3a) and transmission to residential houses (T_RES quartiles; Fig. 6a) were used to assess the priority classes. The classes were ranked from the highest ignition density and transmission to the lowest. | Fig. 8 |
| | Natural fire re-introduction | Lightning ignition density (NAT quartiles; Fig. 5b) and transmission to residential houses (T_RES quartiles; Fig. 6a) were used to assess the classes. The classes were ranked from the highest lightning fire ignition densities to the lowest and from the lowest transmission values to the highest. | Fig. 9 |
| Support a safe and efficient response | Fire suppression | Fire transmission rates to residential houses (TR_RES; Fig. 6c) and wildfire hazard (CFL levels; Fig. 4a) was used to set the classes. The classes were ranked from the highest transmission rates to the lowest and from the lowest hazard levels to the highest. | Fig. 10 |
| Generate fire-adapted communities | Community action | High overall exposure levels (annual HIBP quartiles;Fig. 4b) and number of residential houses on the wildland-urban interface (Alcasena et al., 2018a) were used to set the classes. The classes were ranked from the highest exposure values and the highest number of structures to the lowest. | Fig. 11 |

# Placing the focus back on Resilient Landscapes

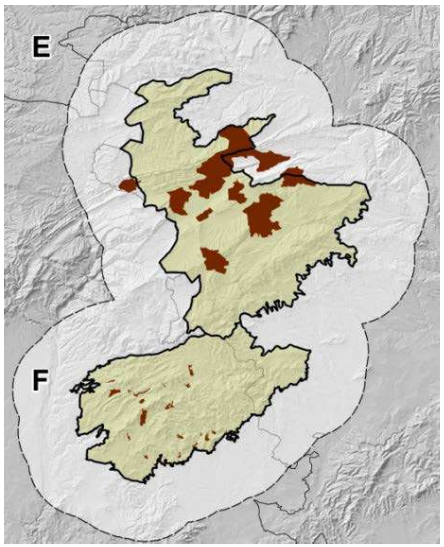
Current situation:

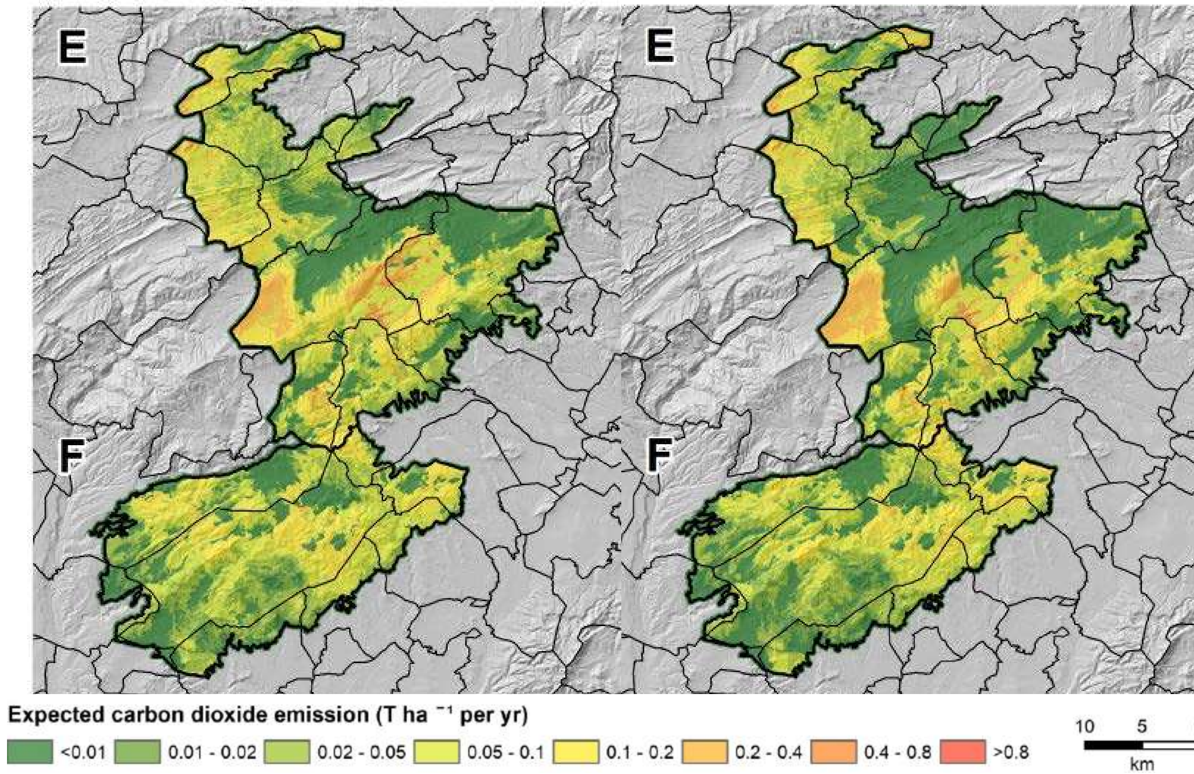
1. Increasing fuel connectivity and buildup are the main contributing factors to large fires in Spain
2. Stand replacing high severity events threaten mature forests and increase future fire hazard by promoting dense regeneration from serotinous conifer species, resprouting shrublands, and coppice stands
3. Managing fuels on fire-prone landscapes represents the most promising strategy capable of reversing the escalation of megafire events and restoring fire resilient ecosystems




Strategic management points GRAF-GenCat, Serres d'Ancosa

Planning fuel treatments to reduce large fire spread is a complex problem and must consider how to efficiently treat landscapes in terms of spatial configuration and density of treatments: how, how much and where?




https://lifeclimark.eu/en/

Technical report 11-12: Effects of fuel treatments on reducing carbon emissions in fire-prone Mediterranean landscapes. Action C5 Strategic fuels management aimed at reducing wildfire risk. 31st March 2019.

How: The use of prescribed fire by landscape managers to treat fuels is gaining importance in fire-prone southern European countries, in fact, until the mid-1950s in many southern EU countries fire was used systematically in rural areas for pasture and edge clearing, and agricultural waste

How much: Besides fuel reduction, prescribed fire can be used to restore habitats, maintain forest canopy openings, facilitate natural regeneration, clear logging debris, control pests and diseases, and improve pastures in mountain areas, but application is not always possible due to the silvicultural state of woodlands

Where: Treatment strategies must consider multiple objectives, which may change substantially the spatial configuration of fuel treatments, but transferable studies are scarce

Rationale:
How does focusing on one fuel management objective result in trade-offs in others, and how to achieve multiple fire management objectives?

Recent studies have explored these questions using production possibility frontiers (PPFs) to graphically represent Pareto efficient optimal resource allocations for competing objectives in fuel treatment programs*

Study case: Optimizing prescribed fire allocation for managing fire risk in central Catalonia

**Ager AA, Day MA, Vogler K. Production possibility frontiers and socioecological tradeoffs for restoration of fire adapted forests. Journal of Environmental Management 2016b; 176: 157-168*

We conducted a case study that combined fire simulation and trade-off analyses to evaluate the compatibility of three prescribed fire management objectives that focused treatments to improve: 1) forest resiliency to fire, 2) effectiveness of fire suppression, and 3) protection of rural communities.

We used optimization methods to examine both trade-offs among the objectives and priorities for sample planning areas.

Bages County, central Catalonia (NE Spain) (Alcasena et al. 2018)

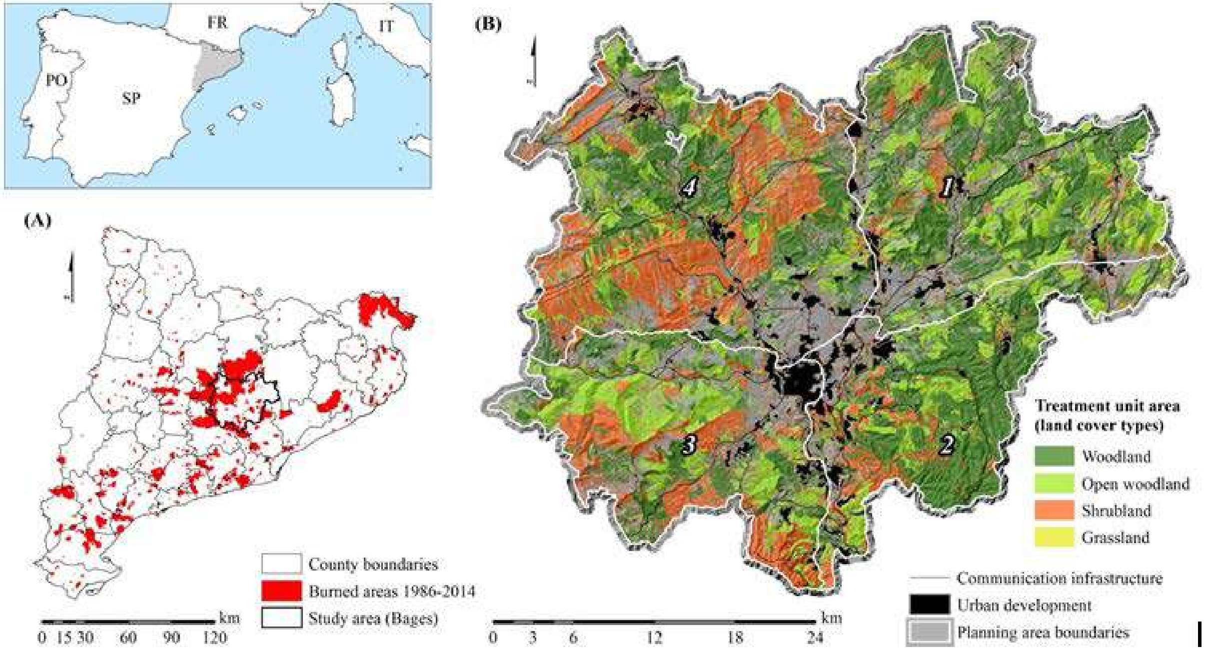
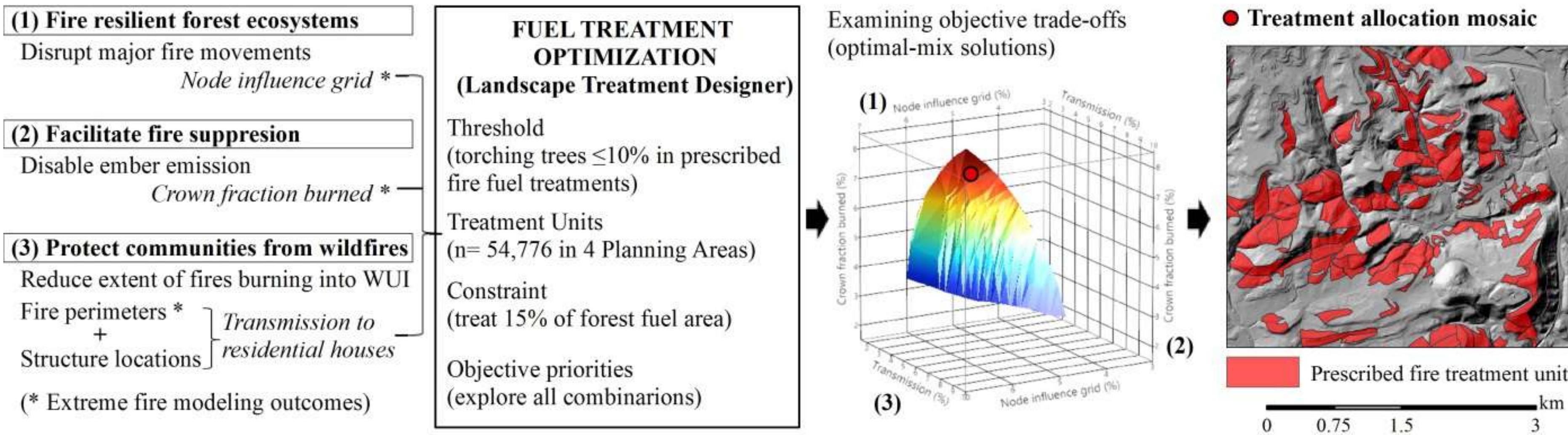



**Fig. 1.** (A) Location of the study area (Bages County, central Catalonia, northeastern Spain) and recent wildfire perimeters (interior.gencat.cat) and (B) planning area boundaries and treatment area by land cover type (agricultura.gencat.cat). Gray areas in (B) are areas ineligible for treatment.

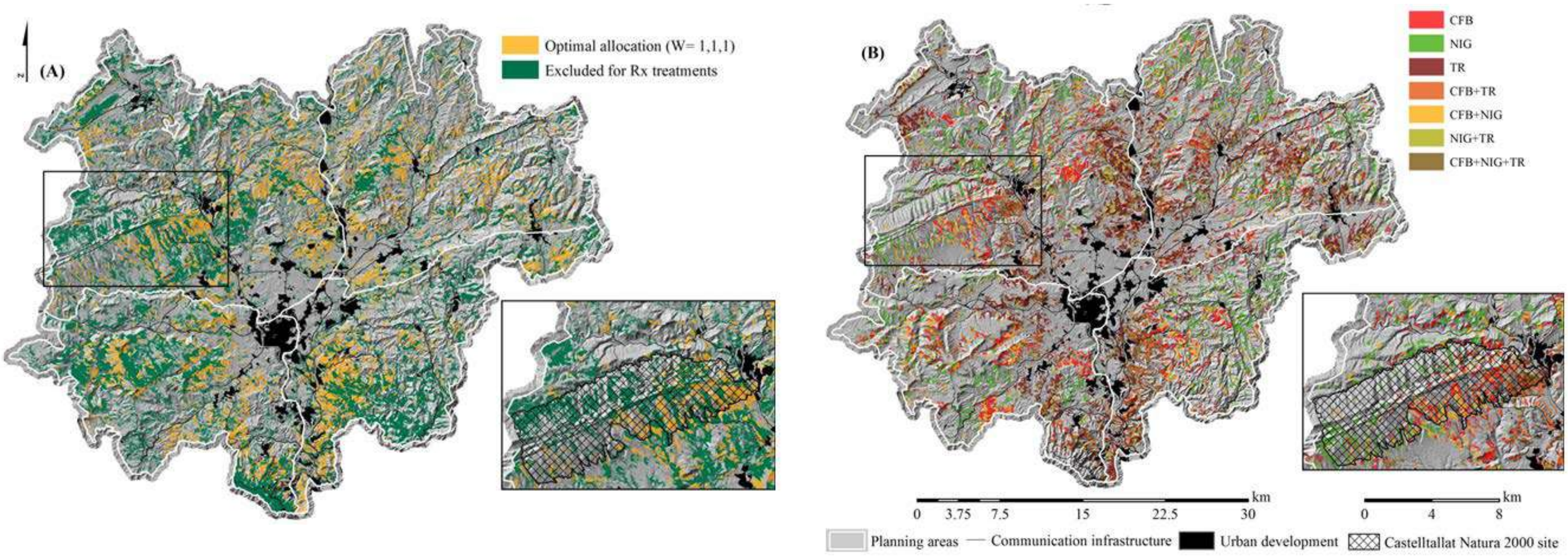
## Graphical abstract:




1. Model fire spread, hazard and exposure metrics under historical extreme fire weather conditions, including node influence grid for surface fire pathways, crown fraction burned and fire transmission to residential structures.

2. An optimization analysis on individual planning areas to identify production possibility frontiers for addressing fire exposure and explore alternative prescribed fire treatment configurations.

# It works…but yet much spatial analysis to do




54,773 treatment polygons based on land cover with an average size of 1.67 ha

**Fig. 9.** . (A) Optimal prescribed fire treatment locations in Bages County (central Catalonia, northeastern Spain) considering the same weights for all three metrics used to assess prescribed fire management objectives (*W*= 1, 1, 1; A). Implementing prescribed fire on densely regenerated young forest stands (e.g., *Pinus halepensis* cohorts with > $10^3$ trees $ha^{-1}$ on 1998 Bages fire burned areas) could cause negative effects on the overstory (average crown fraction burned > 0.1 or torching > 10%), therefore these stands were excluded from the analysis. (B) We overlaid the treatment mosaic results when each metric was optimized independently (see attainments in Fig. 7) to explore areas where optimal solutions for a single metric overlap. The close up view corresponds to the Castelltallat mountain range Natura 2000 site of special interest and Sùria rural community. Abbreviations: CFB= crown fraction burned; TR= transmission; NIG= node influence grid; Rx= prescribed fire.

# ***Thank you……Questions?***

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*In Spanish:*
*Alcasena Urdíroz FJ; C Vega-García; AA Ager; M Salis; NJ Nauslar; FJ Mendizabal; R Castell. 2019. Metodología de evaluación del riesgo de incendios forestales y priorización de tratamientos multifuncionales en paisajes mediterráneos. Cuadernos de investigación geográfica / Geographical Research Letters 45(2):571-600.*