Ana Martín, Brigite Botequim,
Alan Ager, Tiago M. Oliveira

SSAFR

Symposium on Systems Analysis in Forest Resources

"A three-tiered technique to prioritise fuel treatments and analyse trade-offs under multi-objectives"

August 28, 2018

ana.martin@uva.es

SUMMARY:

I. Relevance of the problem

- *Reviewing the evidence*

II. Challenges and ideas

- *Purpose of the research*

III. Research design

- *Case study*
- Three-step approach for decision-making in eucalyptus forest

IV. Outcomes analyses

- *Results & Discussion*

V. Considerations

I. Relevance of the problem

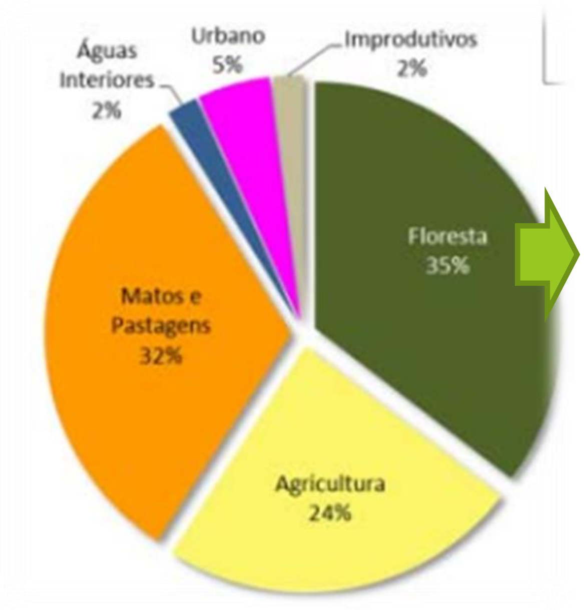
I. BACKGROUND

- The management of sustaining forest ecological base, in a changing socio-economic, demographic and political context is a challenge…

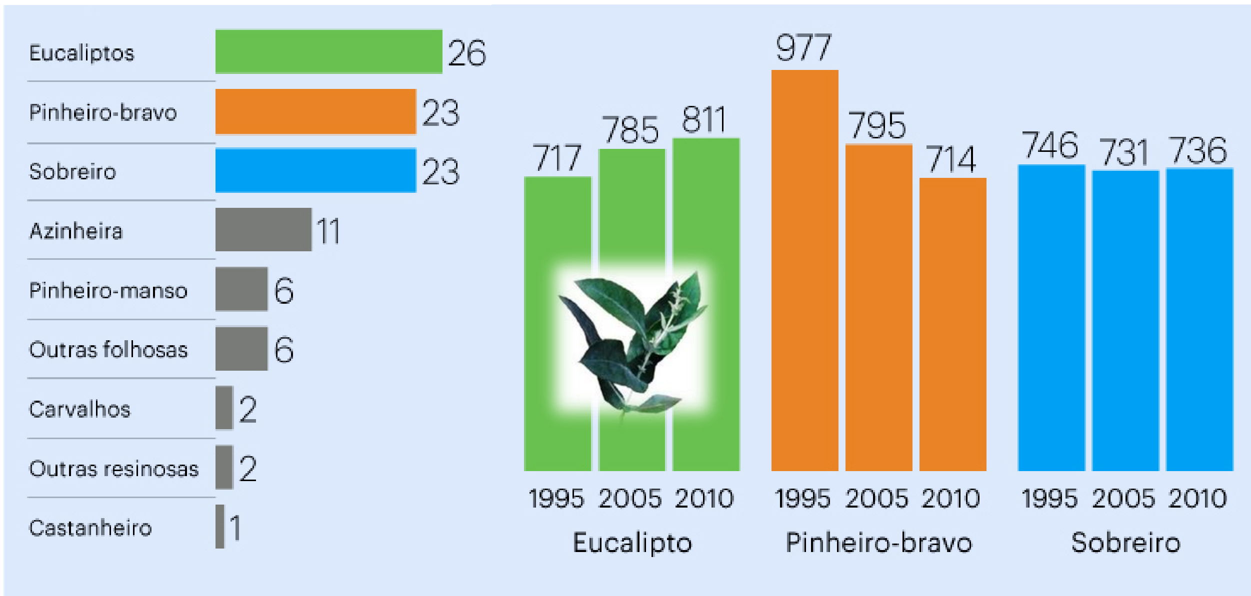
- Understanding wildfire behavior first at stand-level and landscape-level is critical to address wildfire impacts in Portuguese forest management planning
- Preventive silviculture management is a dynamic instrument needing knowledge about the localization of the critical points to address

I. EVIDENCE | Forest species

- Plantations dominated by **eucalypts encompass 811 thousand hectares**



26% of the whole forested area



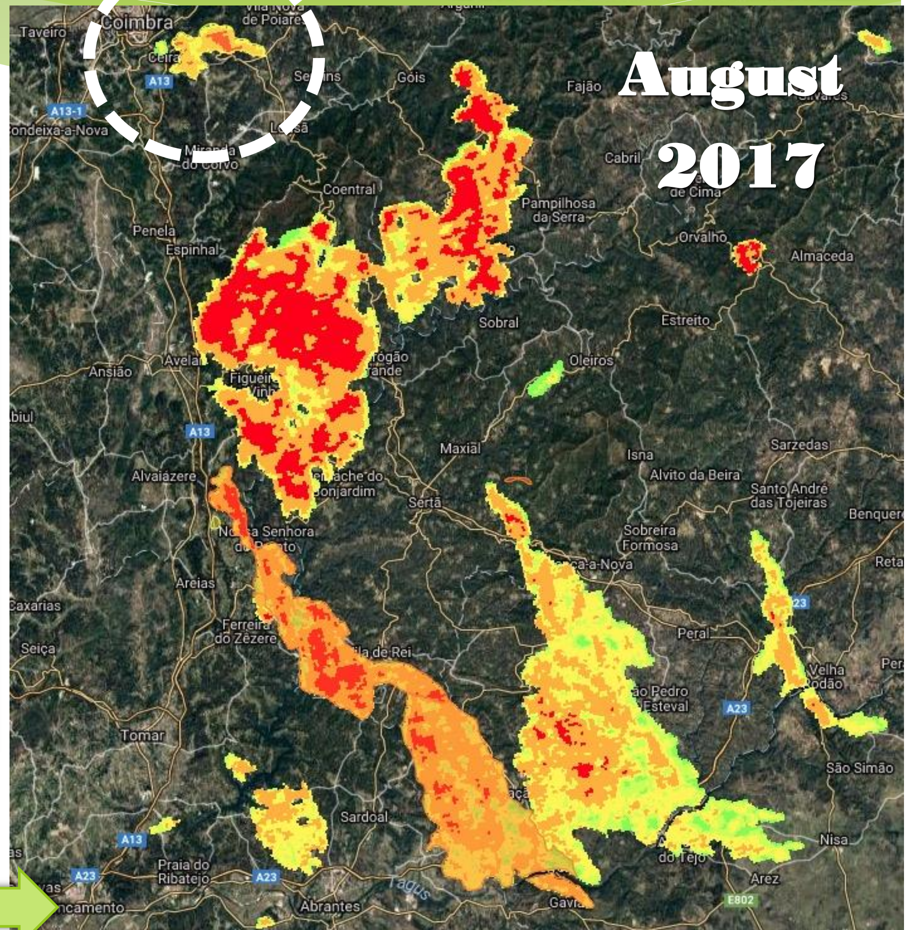
- resulting in the **main forest cover type in continental Portugal**

I. EVIDENCE | Forest fires

| PORTUGAL

- Burned area of central Portugal
  (red = more severity)

The fires have left deep wounds in the tight knit agricultural communities of central Portugal



A total of <u>150 thousand hectares</u>

Photo: GOIS, Portugal | August 2017

EFFIS| Screen Shot 2017-08-26

I. EVIDENCE | Forest fires

| Pedrogão Grande

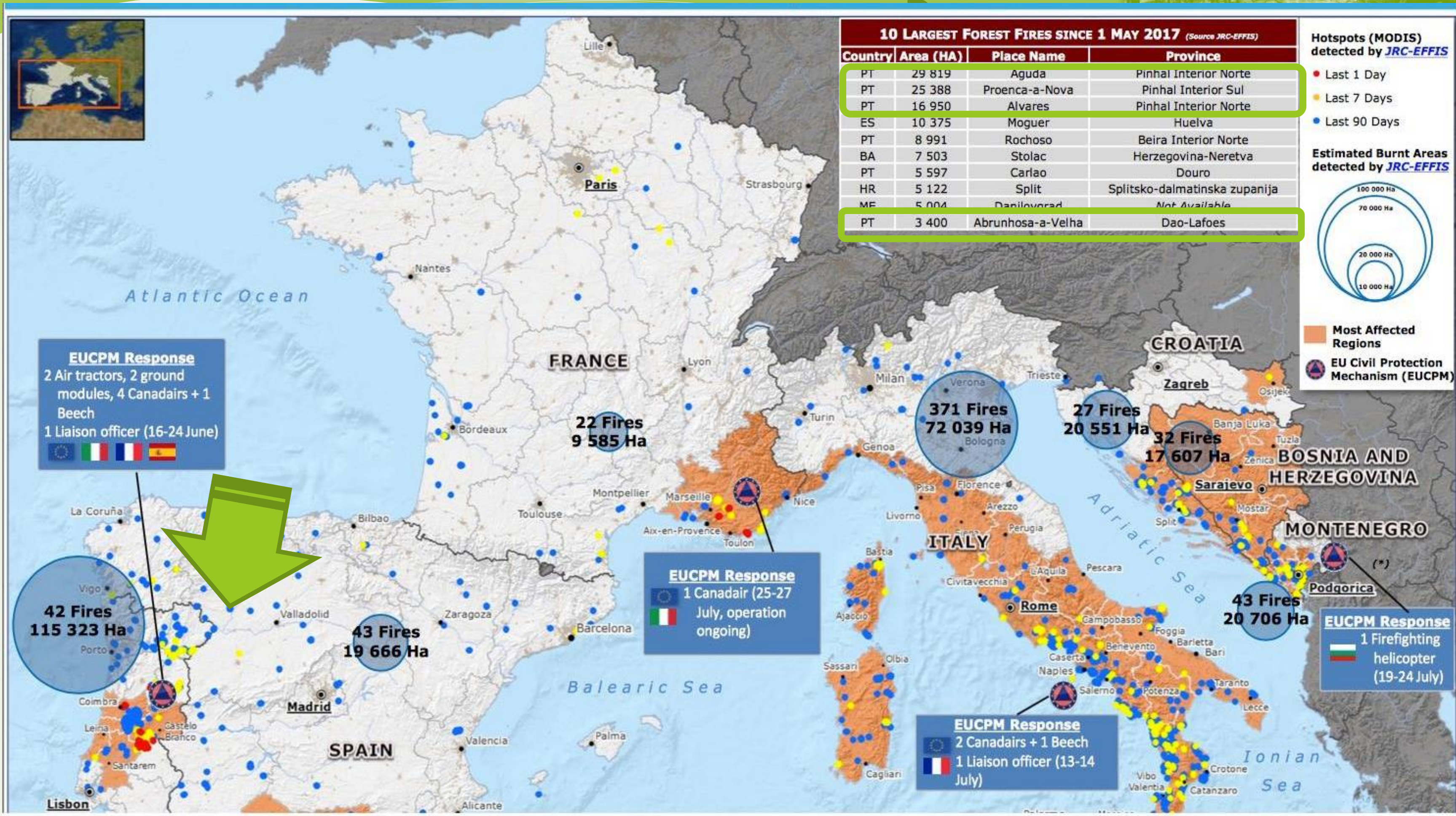
| PORTUGAL

Portugal has become a particularly stark case of what the future may hold if changes to land, climate and economies go mismanaged!

Photo: NASA, August 2016

I. EVIDENCE | Forest fires

| Forest Fires in Southern Europe (Previous 90)



10 Largest Forest Fires since 1 May 2017 *(Source JRC-EFFIS)*

Country	Area (HA)	Place Name	Province
PT	29 819	Aguda	Pinhal Interior Norte
PT	25 388	Proenca-a-Nova	Pinhal Interior Sul
PT	16 950	Alvares	Pinhal Interior Norte
ES	10 375	Moguer	Huelva
PT	8 991	Rochoso	Beira Interior Norte
BA	7 503	Stolac	Herzegovina-Neretva
PT	5 597	Carlao	Douro
HR	5 122	Split	Splitsko-dalmatinska zupanija
ME	5 004	Danilovgrad	Not Available
PT	3 400	Abrunhosa-a-Velha	Dao-Lafoes

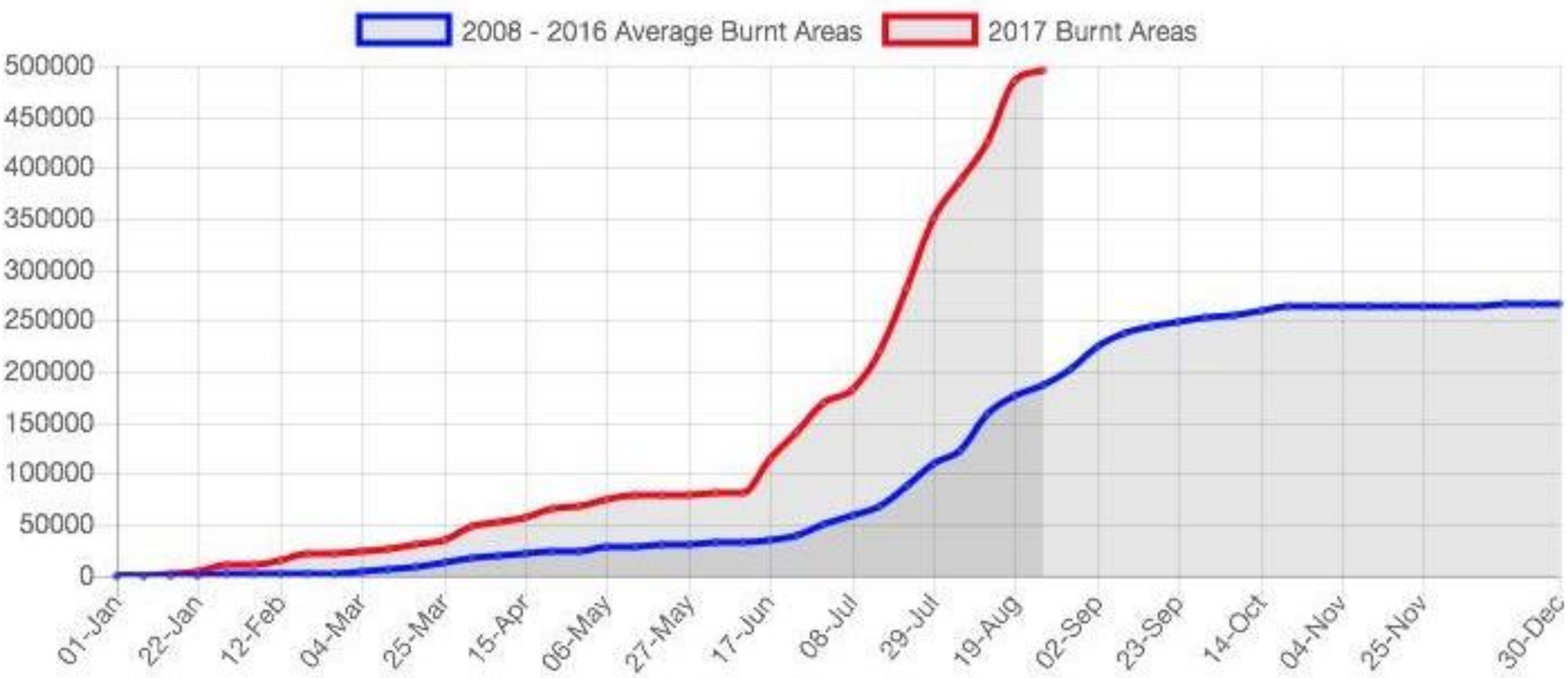
ERCC - ECHO Daily Map | **27/07/2017**

I. EVIDENCE | Forest fires

| SEASONAL TREND – TOTAL EU

The area burned in the EU this year is half a million hectares

- ❑ **Burnt areas mapped in EFFIS ***



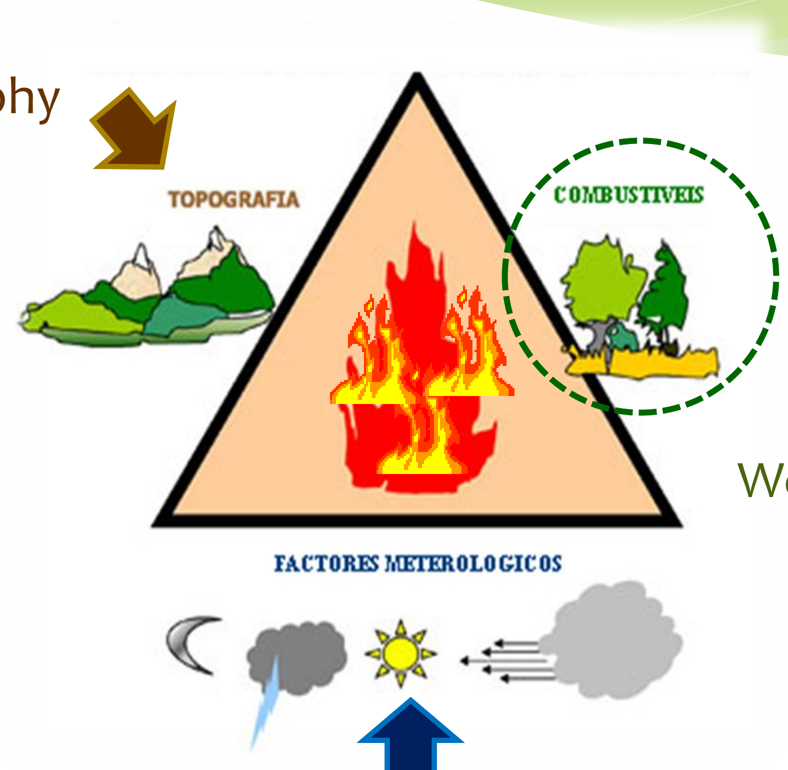
Portugal with **200,000 ha** represents <u>**40% of the total!**</u>

*EFFIS , August 17

I. EVIDENCE | Forest fires

- Three factors comprise the fire behavior triangle :

The area’s topography



The amount of fuel

We can lower fire risk and wildfire damage by **removing** or **reducing** fuels in strategic locations…

Weather conditions

II. CHALLENGES AND IDEAS

Forest Systems
25(2), eRC09, 9 pages (2016)
eISSN: 2171-9845
http://dx.doi.org/10.5424/fs/2016252-09293
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESOURCE COMMUNICATION

OPEN ACCESS

Temporal optimisation of fuel treatment design in blue gum (*Eucalyptus globulus*) plantations

Ana Martín[1], Brigite Botequim[2]*, Tiago M. Oliveira[3], Alan Ager[4], Francesco Pirotti[5]

[1] Sustainable Forest Management Research Institute University of Valladolid-INIA, Avda de Madrid 44, 3004 Palencia, Spain. [2] Centro de Estudos Florestais (CEF), Instituto Superior de Agronomia, Universidade de Lisboa (UL). Edifício Mário de Azevedo Gomes Tapada da Ajuda, n/s, 1349 - 017, Lisboa, Portugal. [3] The Navigator Company, Forest Protection Department, Apartado 55, 2901-861 Setúbal, Portugal. [4] USDA Forest Service, Rocky Mountain Research. 5775 Highway 10 West, Missoula, MT 59808 USA. [5] Università degli Studi di Padova, Dipartimento Territorio e Sistemi Agro-forestali. Viale dell'Universita, 16, 35020, Padova, Italy

Abstract

Aim of study: This study was conducted to support fire and forest management planning in eucalypt plantations based on economic, ecological and fire prevention criteria, with a focus on strategic prioritisation of fuel treatments over time. The central objective was to strategically locate fuel treatments to minimise losses from wildfire while meeting budget constraints and demands for wood supply for the pulp industry and conserving carbon.

Area of study: The study area was located in Serra do Socorro (Torres Vedras, Portugal, covering ~1449 ha) of predominantly *Eucalyptus globulus* Labill forests managed for pulpwood by The Navigator Company.

Material and methods: At each of four temporal stages (2015-2018-2021-2024) we simulated: (1) surface and canopy fuels, timber volume ($m^3\ ha^{-1}$) and carbon storage ($Mg\ ha^{-1}$); (2) fire behaviour characteristics, i.e. rate of spread ($m\ min^{-1}$), and flame length (m), with FlamMap fire modelling software; (3) optimal treatment locations as determined by the Landscape Treatment Designer (LTD).

Main results: The higher pressure of fire behaviour in the earlier stages of the study period triggered most of the spatial fuel treatments within eucalypt plantations in a juvenile stage. At later stages fuel treatments also included shrublands areas. The results were consistent with observations and simulation results that show high fire hazard in juvenile eucalypt stands.

Research highlights: Forest management planning in commercial eucalypt plantations can potentially accomplish multiple objectives such as augmenting profits and sustaining ecological assets while reducing wildfire risk at landscape scale. However, limitations of simulation models including FlamMap and LTD are important to recognise in studies of long term wildfire management strategies.

Keywords: Eucalypt plantations; fire hazard; FlamMap; fuel treatment optimisation; Landscape Treatment Designer; wildfire risk management.

Citation: Martín, A., Botequim, B., Oliveira, T.M., Ager, A., Pirotti, F. (2016). Temporal optimisation of fuel treatment design in blue gum (*Eucalyptus globulus*) plantations. Forest Systems, Volume 25, Issue 2, eRC09. http://dx.doi.org/10.5424/fs/2016252-09293.

Received: 13 Jan 2016. **Accepted**: 05 May 2016

Funding: The authors received no specific funding for this research.

Where to treat?
When to treat?
How should be applied?
Shape and size?

II. CHALLENGES AND IDEAS

| Purpose of the research :

- reduce **<u>spatial-temporal fire exposure at landscape-level under multi-objectives</u>** to reduce fuel accumulation

- support **fire and forest management planning** in fast-growing forest plantations based on **<u>economic</u>**, **<u>ecological</u>** and **<u>fire prevention</u>** criteria

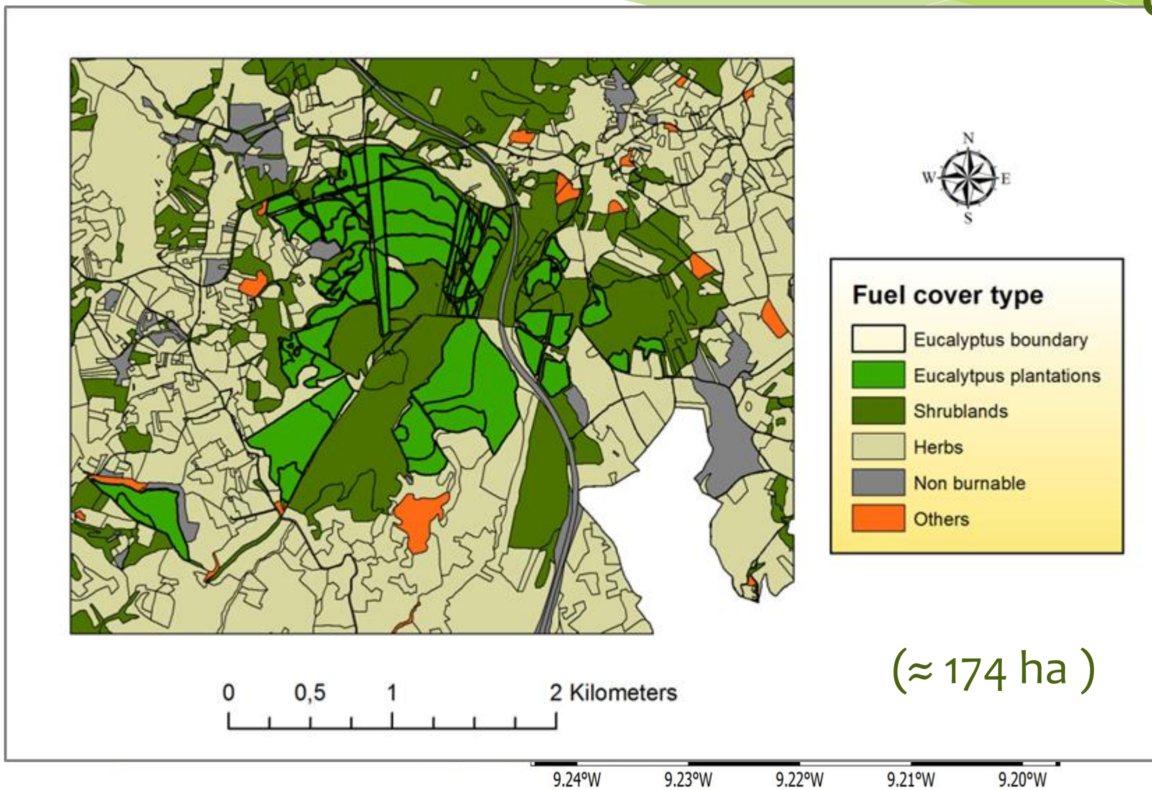
- **<u>A multi-objective planning was performed to strategically locate fuel treatments :</u>**
  - to minimise losses from wildfire
  - Meeting seasonal budget constraints for prevention activities
  - Maximize demands for wood supply for the pulp industry
  - maximize demands of carbon storage

III. RESEARCH DESIGN

|Serra do Socorro (Torres Vedras, central Portugal)

Case study

(≈ 1449 ha)



- *Eucalyptus globulus forest plantation cultivated for pulpwood by The Navigator Company - the leading paper company in Europe.*

III. RESEARCH DESIGN

Case study

- Set of different stages of eucalyptus plantations in Serra do Socorro

- **Four temporal stages**
  - 2015 (t=0)
  - 2018 (t=1)
  - 2021 (t=2)
  - 2024 (t=3)

III. RESEARCH DESIGN

| Three-step approach for decision-making in eucalyptus forest

I. Fuel Dynamic Trends
(Growth and Yield model, surface and canopy fuels)
(Web – Globulus/Globulus 3.0)

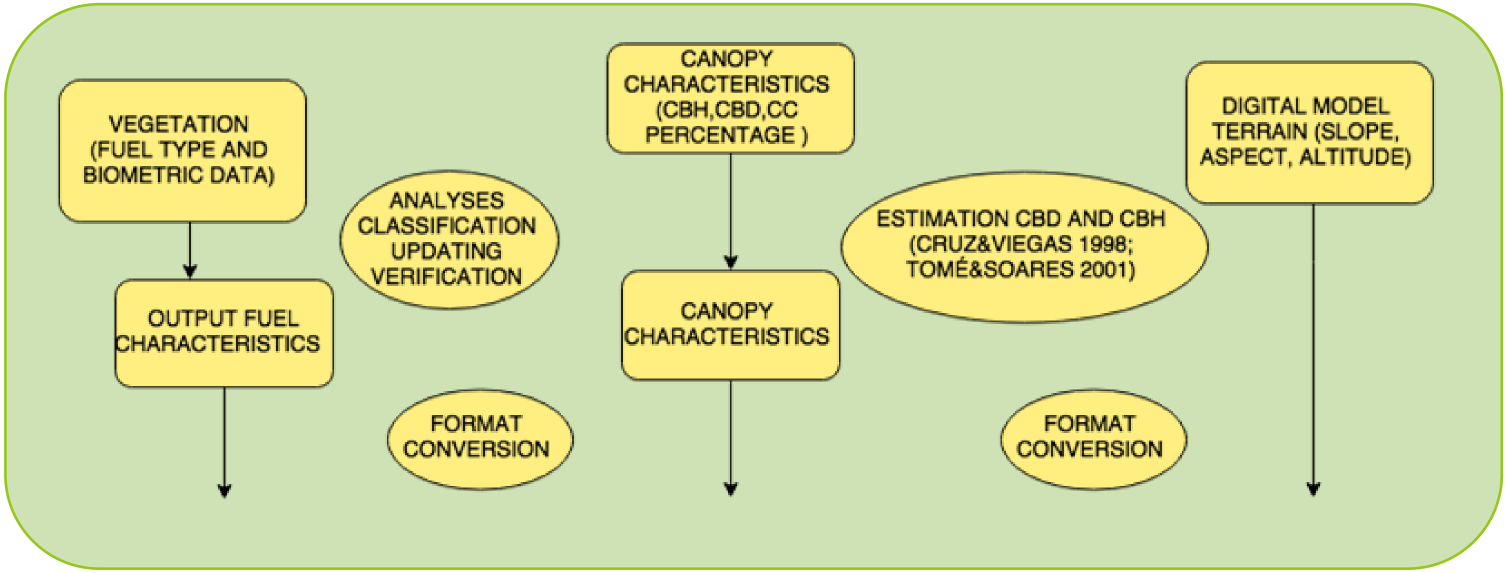
II. Fire behaviour metrics (ROS & FL metrics)
(FlamMap)

III. Optimal configurations for fuel treatments
(LTD New version)

III. RESEARCH DESIGN

| Three step approach

I. Fuel Dynamic Trends



- Identifying fuel composition and stand conditions at temporal stage with the assistance of the growth and yield model

A. Growth and Yield model

| Simulating stand-level growth

B72 =(29,0669+0,288*H8)*((B71/(29,0669+0,288*H8))^((A71/A72)^0,489))

GLOBULUS 3.0

...)06 M. Tomé, T. Oliveira, P. **Soares**. O modelo Globulus 3.0. Publicações GIMREF - RC2/2006. Departamento de Engenharia Florestal, Instituto Superior de Agronomia, Lisb...

Tabela de produção construída com base no modelo Globulus - local: Quinta do Paço

Parâmetros iniciais		Dados de clima	
rotação	0	dias de precipit	105
densidade à plantação (ha-1)	1250	altitude (cota)	150
idade de corte (anos)	10	dias geada	8
diâmetro desponta (cm)	5	temper. (°C)	14
		precip. (mm)	800

CENÁRIO 1 - EXISTÊNCIA DE DADOS DE INVENTÁRIO

Dados de inventário	
idade (anos)	1,0
hdom (m)	14,0
N (ha-1)	1100
G (m2 ha-1)	10,0

densidade à plantação: 1113,1 / 1113,2 / 1111

t (anos)	hdom (m)	N (ha^{-1})	G $m^2 ha^{-1}$	Vsccc $[m^3 ha^{-1}]$	Vcasca $[m^3 ha^{-1}]$	Vcccc $[m^3 ha^{-1}]$	dg (cm)	Vcepo $m^3 ha^{-1}$	Vmsc $m^3 ha^{-1}$	Wl Mg ha-1	Wbr Mg ha-1	Ww Mg ha-1	Wb Mg ha-1	Wt Mg ha-1	W raiz Mg ha-1	Wtotal Mg ha-1	Cl Mg ha-1	Cbr Mg ha-1	Cw Mg ha-1	Cb Mg ha-1
1,0	**14,0**	**1100**	**10,0**	52,4	12,1	64,5	10,8	1,400	48,308	4,962	4,737	23,756	3,664	37,118	9,23	46,349	2,441	2,245	11,640	1,715
2	21,2	1086	19,3	143,2	31,2	180,4	15,0	2,924	143,513	8,447	9,628	76,167	10,976	105,218	26,17	131,385	4,156	4,564	37,322	5,137
3	25,5	1072	25,9	236,8	47,5	284,3	17,5	4,035	####	10,577	13,197	127,881	18,037	169,693	42,20	211,895	5,204	6,256	62,662	8,441
7	34,0	1018	40,8	478,8	89,7	568,5	22,6	6,518	####	14,063	21,270	281,760	39,980	357,072	88,80	445,876	6,919	10,082	138,062	18,711
8	35,2	1005	43,1	521,2	96,8	618,0	23,4	6,896	511,982	14,368	22,500	####	44,336	#####	97,22	488,112	7,069	10,665	151,749	20,749
9	36,2	992	45,1	559,0	103,1	662,0	24,1	7,221	####	14,559	23,553	####	48,393	421,133	104,74	525,869	7,163	11,164	163,968	22,648
12	38,6	954	50,0	651,2	118,2	763,4	25,8	7,973	641,121	14,672	25,951	####	59,225	495,273	123,17	618,448	7,219	12,301	193,758	27,717

CENÁRIO 2 - NÃO EXISTÊNCIA DE DADOS DE INVENTÁRIO

Sem dados de inventário			
IQE (m)	19,0	densidade à plantação (ha-1)	1250

t (anos)	hdom (m)	N (ha^{-1})	G $m^2 ha^{-1}$	Vsccc $[m^3 ha^{-1}]$	Vcasca $[m^3 ha^{-1}]$	Vcccc $[m^3 ha^{-1}]$	dg (cm)	Vcepo $m^3 ha^{-1}$	Vmsc $m^3 ha^{-1}$	Wl Mg ha-1	Wbr Mg ha-1	Ww Mg ha-1	Wb Mg ha-1	Wt Mg ha-1
1	1,8	1234	0,3	0,2	0,1	0,3	1,8	0,023	0,000	0,270	0,124	0,060	0,014	0,468
2	4,9	1217	1,7	2,9	0,9	3,8	4,2	0,159	1,082	1,099	0,665	1,087	0,194	3,046
3	7,6	1201	3,5	9,4	2,6	12,0	6,1	0,370	6,792	2,033	1,405	3,938	0,623	7,999
4	10,0	1185	5,4	18,9	4,8	23,8	7,6	0,610	15,891	2,909	2,192	8,484	1,253	14,838
5	12,0	1170	7,3	30,4	7,4	37,8	8,9	0,856	27,075	3,689	2,966	14,312	2,026	22,993
6	13,8	1154	9,0	43,0	10,2	53,3	10,0	1,097	39,515	4,368	3,703	21,032	2,895	31,998
7	15,3	1139	10,7	56,4	13,1	69,5	10,9	1,330	52,660	4,953	4,395	28,337	3,829	41,513

Sheet1

(Globulus 3.0., Tomé et al. 2006)

Driven by:

- Environmental-climatic
- Stand characteristics (management)
- Biometric data

Outputs:

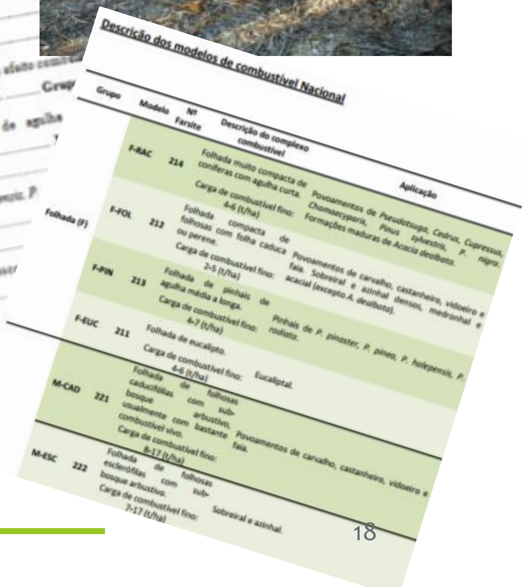
- Biometric variables (input FlamMap by canopy eq.)
- Dominant Height
- Wood volume and total biomass

B. Dynamic fuel population

- **The fuel model type and canopy cover (CC, %) change over time due to planting operations, harvesting, and vegetation regrowth**

- Identification fuel model key
- Fuel load characterisation
- Expert knowledge from the mill´s pulp and paper company


de identificação dos modelos de combustível


Descrição dos modelos de combustível Nacional

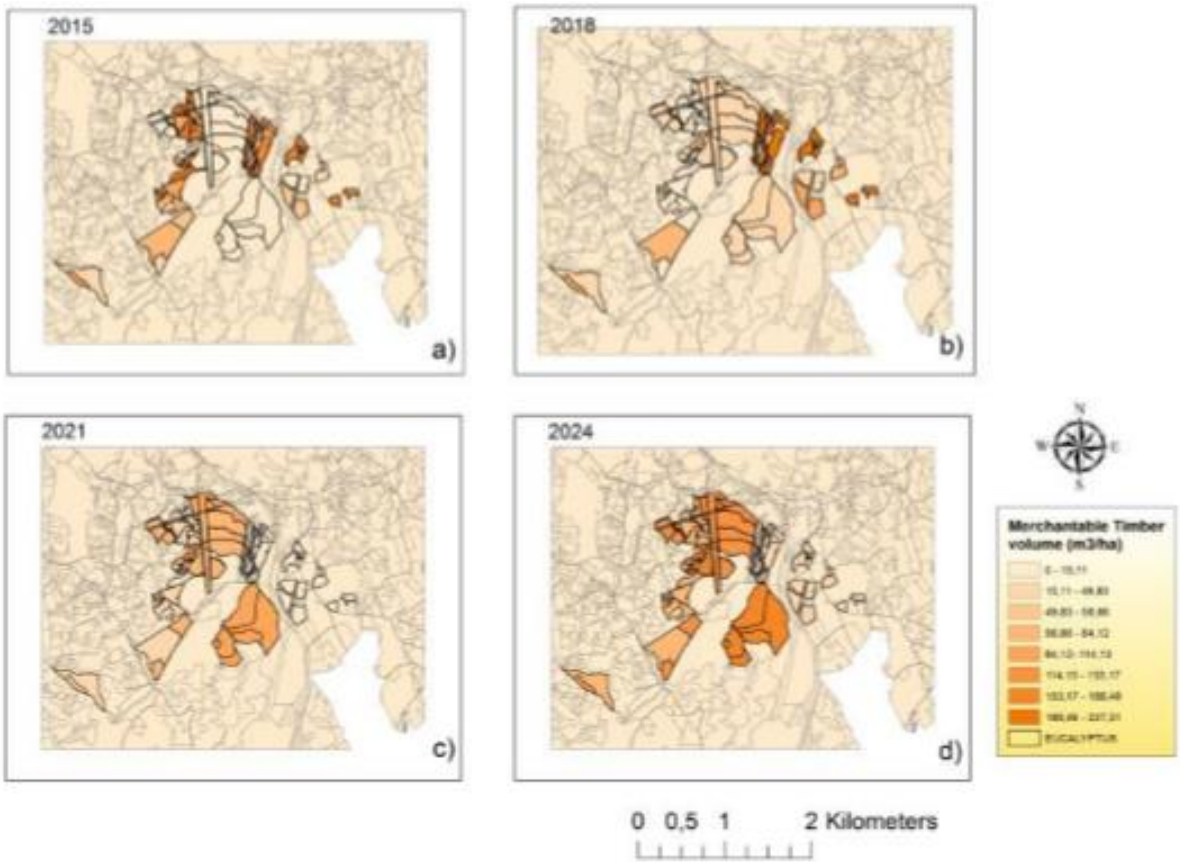
Grupo	Modelo	Nº Farsite	Descrição do complexo combustível	Aplicação
Folhada (F)	F-RAC	214		
	F-FOL	212		
	F-PIN	213		
	F-EUC	211	Folhada de eucalipto.	Eucaliptal.
	M-CAD	221		
	M-ESC	222		Sobreiral e azinhal.

Outputs:
- Fuel model type
- CC percentage

Fernandes et al., 2009

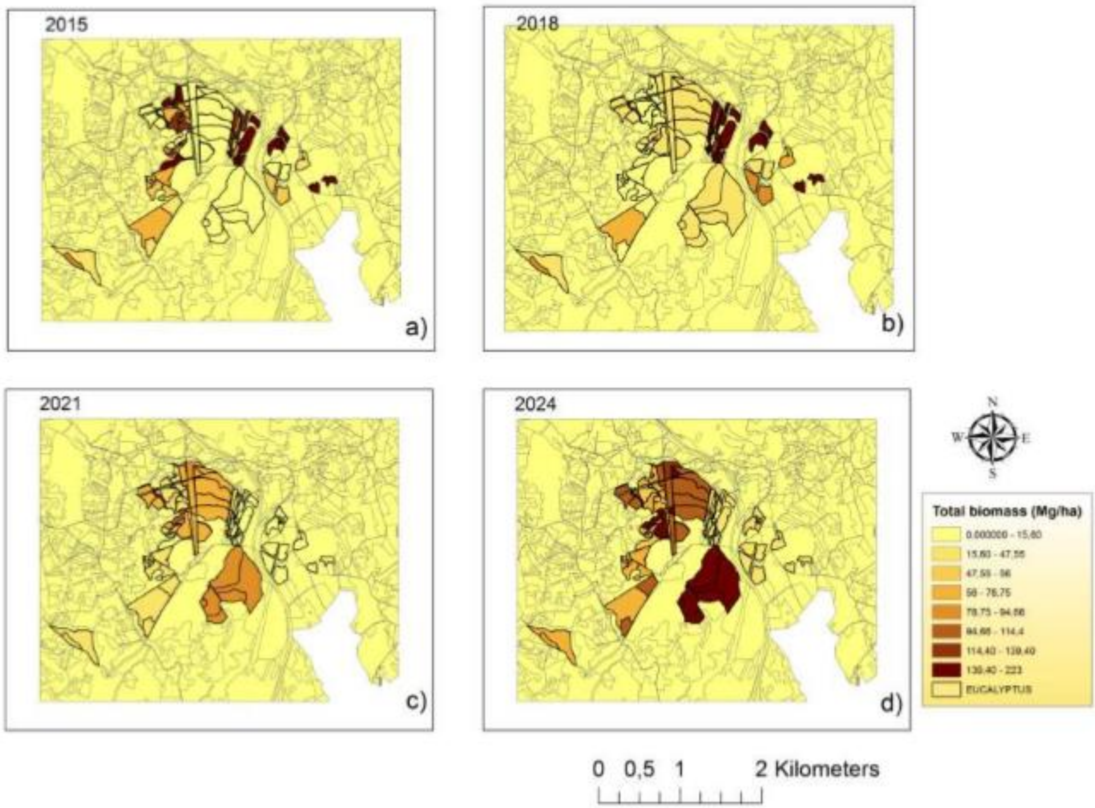
C. Fuel dynamic trends

❑ Merchantable Timber volume (m3/ha)



D. Fuel dynamic trends

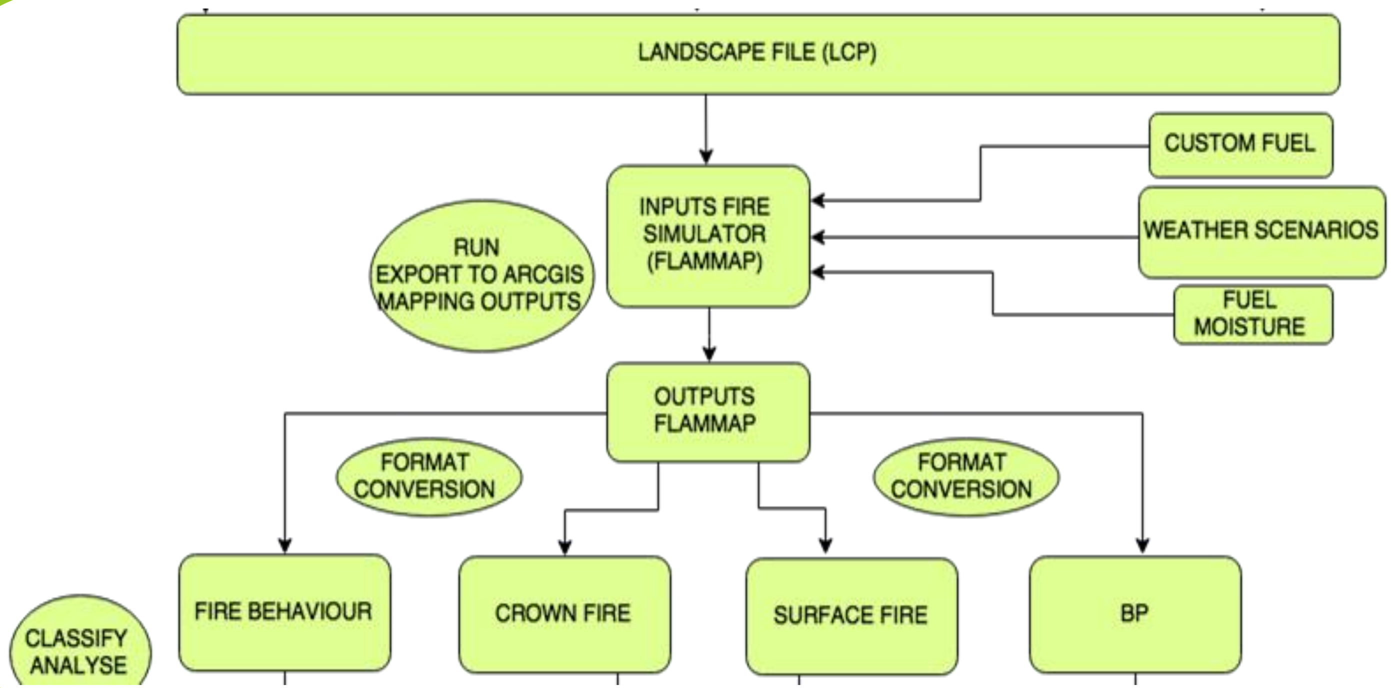
❑ Total Biomass (Mg/ha)



III. RESEARCH DESIGN

| Three step methodology

II. Fire behaviour metrics

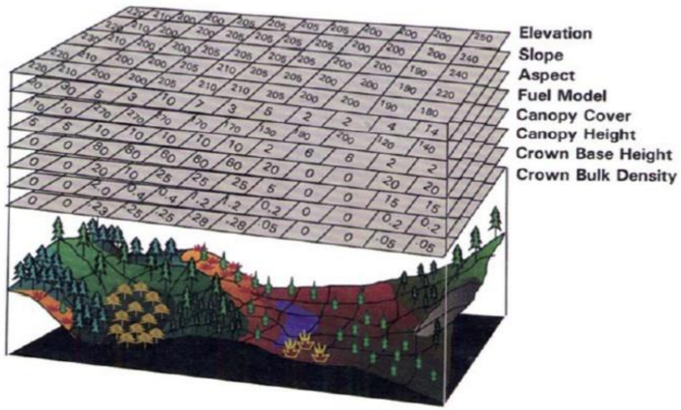


- Characterizing fire behaviour over time

C. Fire Behaviour metrics

Inputs: fire environment fuel& weather& topography

LCP file:



(Finney 2003)

- Fuel and canopy cover
- Canopy characteristics: CBD, CBH
- DTM
- 7% 1-hour fuel moisture content (97th percentile weather during fire season)
- Wind data-32km/h, Northwest, 320° azimuth direction
- Fuel custom type

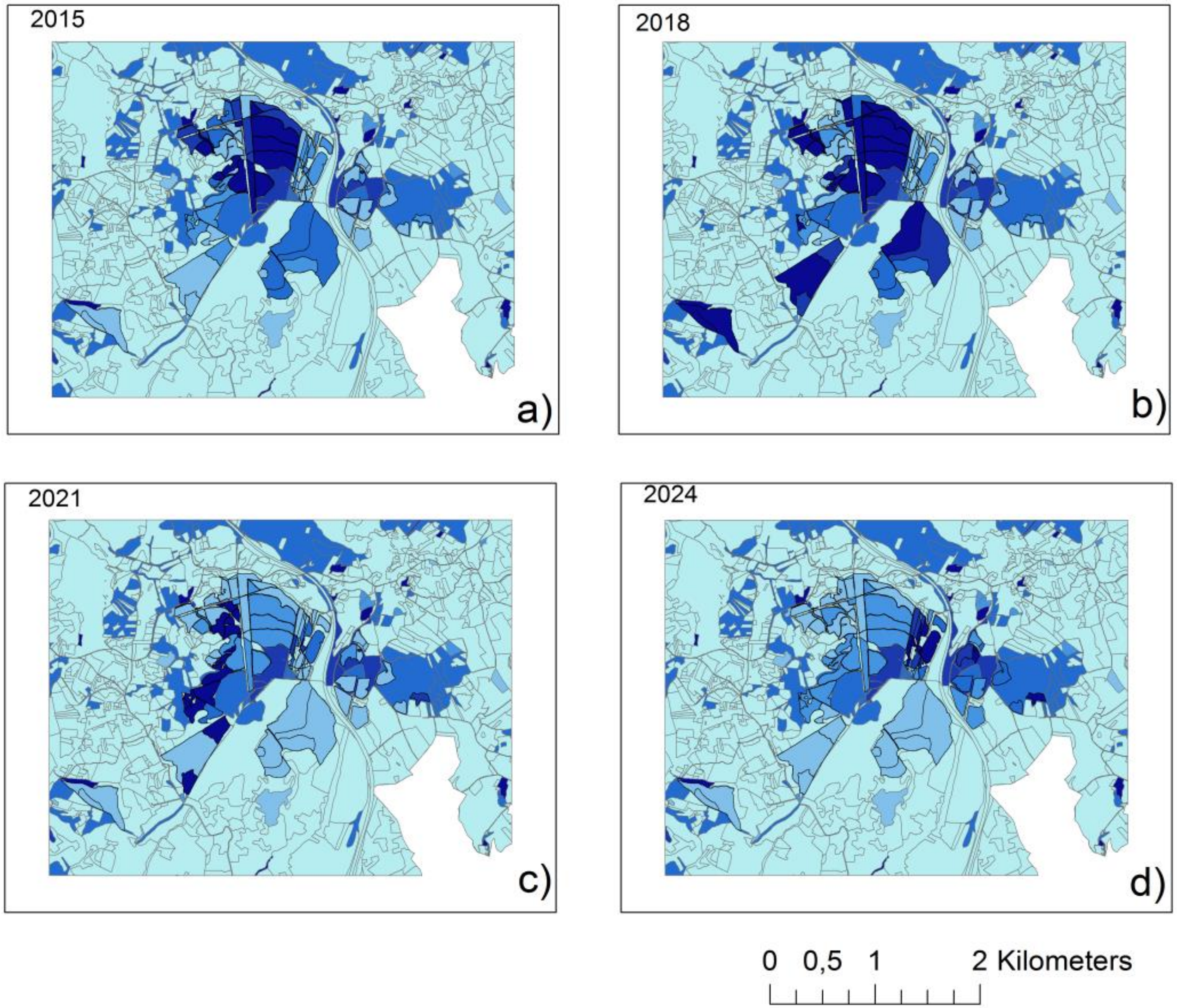
- Fire behaviour metrics

Outputs

FireGlobulus project January 2015

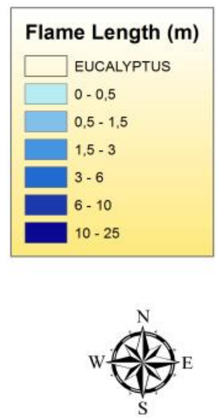
C. Fire Behaviour metrics

| Assessing flame length over time



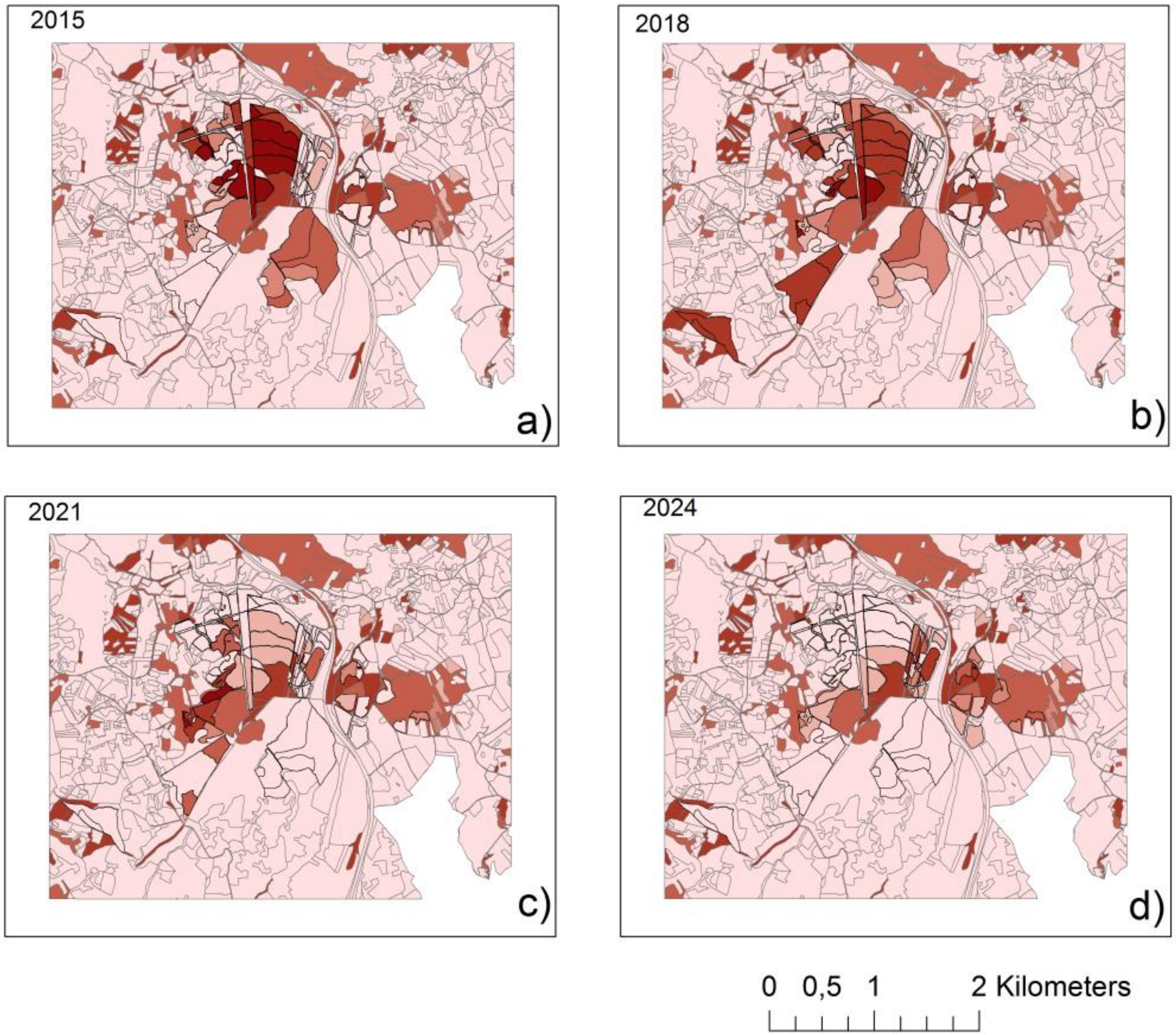
<3m in b)
>3 m in a)

Fuel type and fire hazard associated?



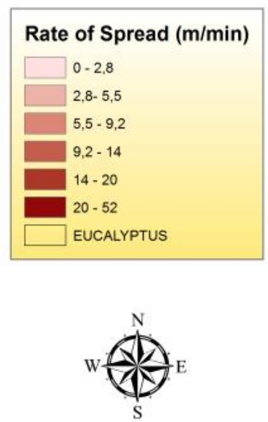
C. Fire Behaviour metrics

| Assessing rate of spread over time



<14 m/min in c)d)
>14 m/min in a)b)

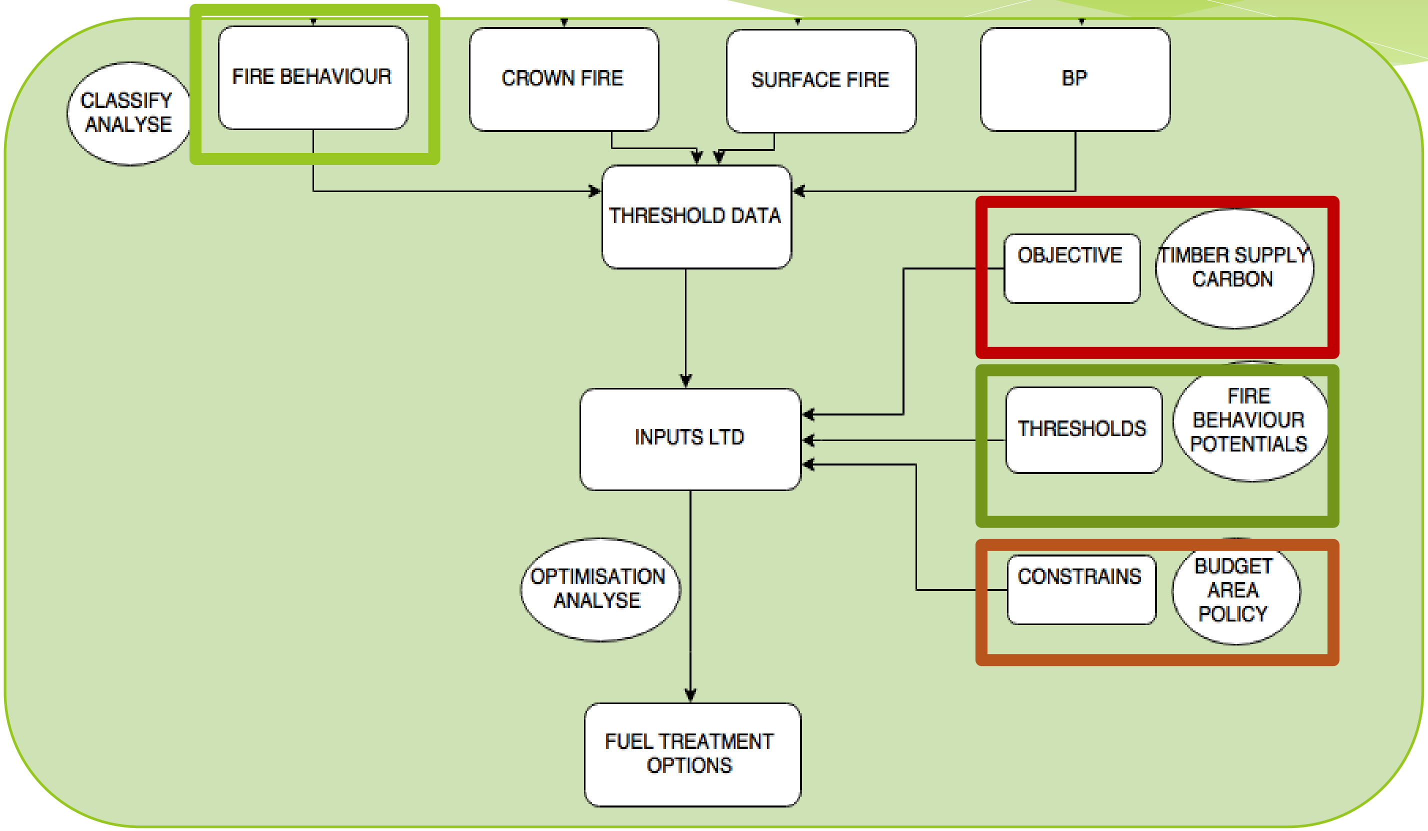
CC% asociated?



III. RESEARCH DESIGN

| Three step methodology

III. Optimal configurations for treatment locations



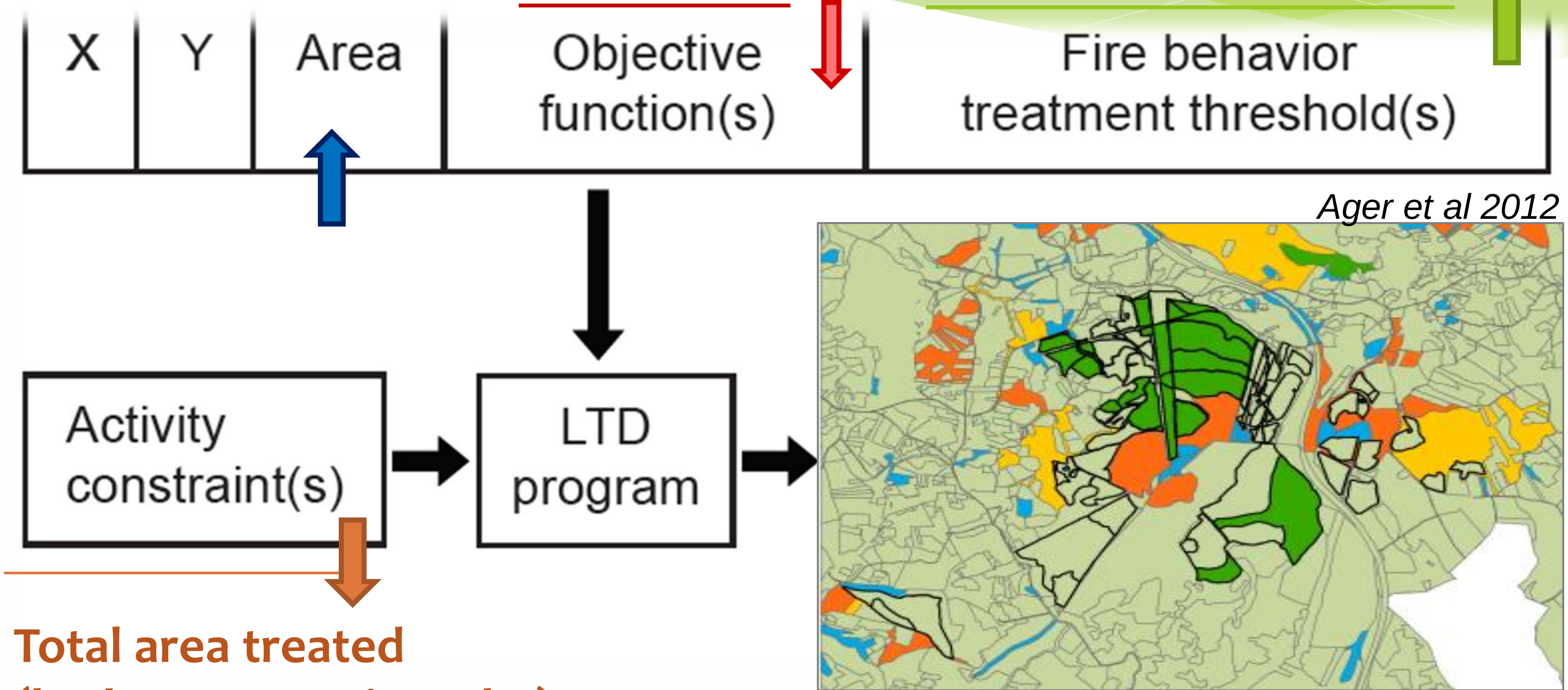
D. Optimal levels for fuel treatments

| Input LTD

The Navigator CS

Max timber volume (kg/m3) & carbon storage (Mg/ha)

Fire metrics (FL >1.5m , ROS>10m/min)



Ager et al 2012

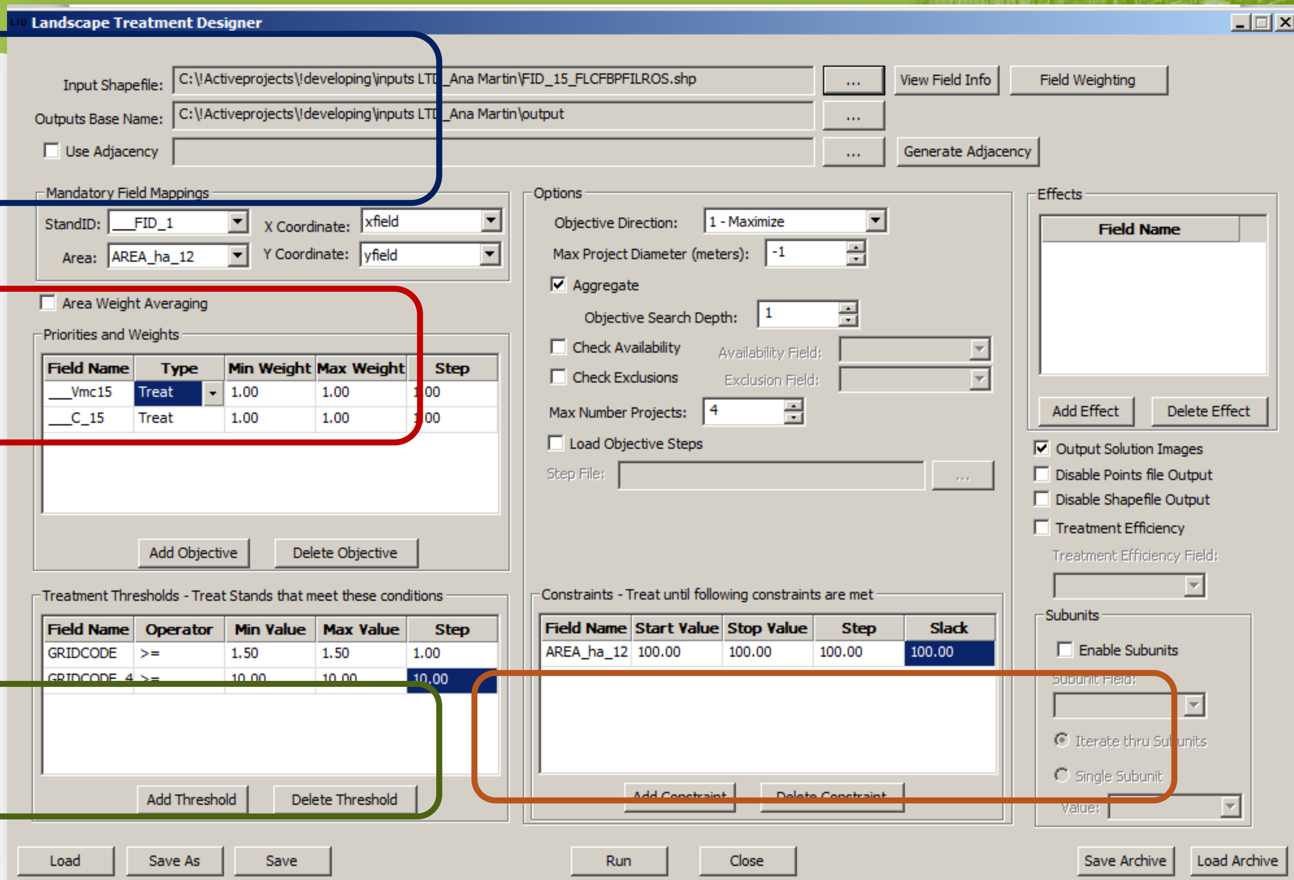
Total area treated (budget constrain=70ha)

prioritization of project areas for fuel treatments

D. Optimal levels for fuel treatments

| LTD simulation

- Fuel treatment allowance level intensity about **4% for the whole landscape**
- 40% of the area within eucalypt plantations



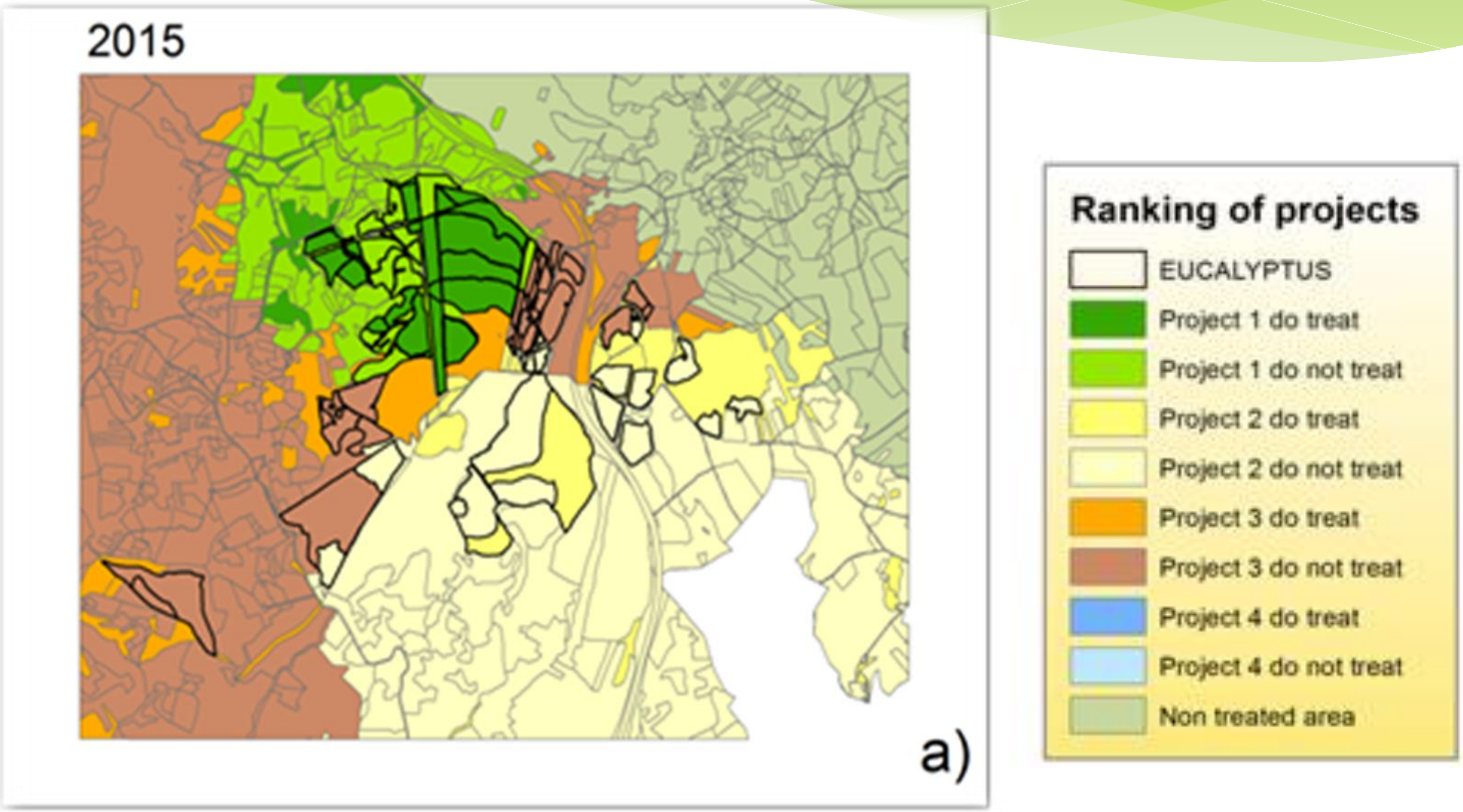
Ager, A.A.; Vaillant, N.M.; McMahan, A. 2013. *Restoration of fire in managed forests: a model to prioritize landscapes and analyze tradeoffs.* Ecosphere 4:art29.

IV. OUTCOMES ANALYSES

AGGREGATE

|Assessing strategic fuel location - 70 ha

- coordination of treatment to build large patches

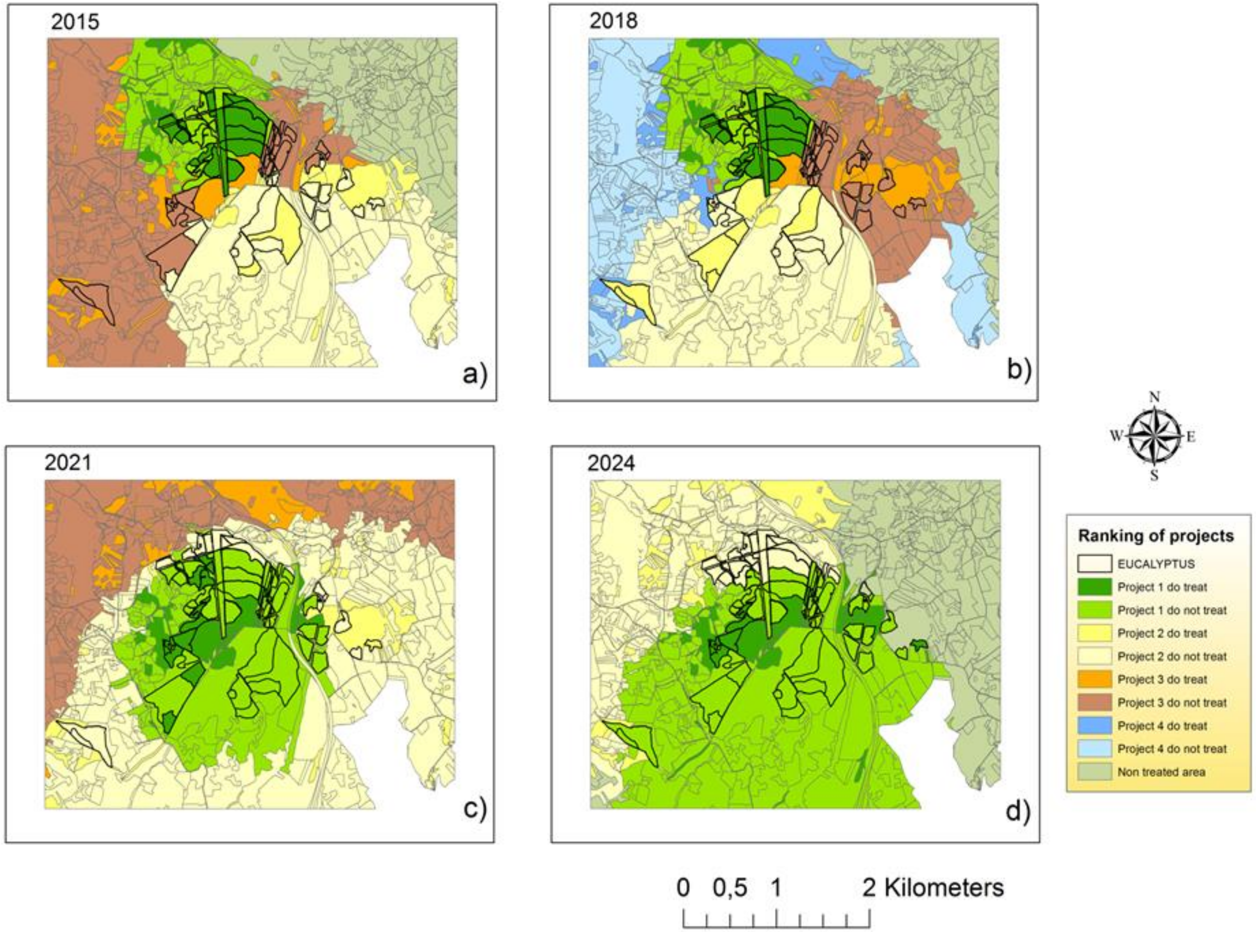


IV. OUTCOMES ANALYSES

|Assessing strategic fuel location - 70 ha

The results were consistent with observations and simulation results that show **high fire hazard in juvenile eucalypt stands**

ROS and FL decrease over time, number of project decrease

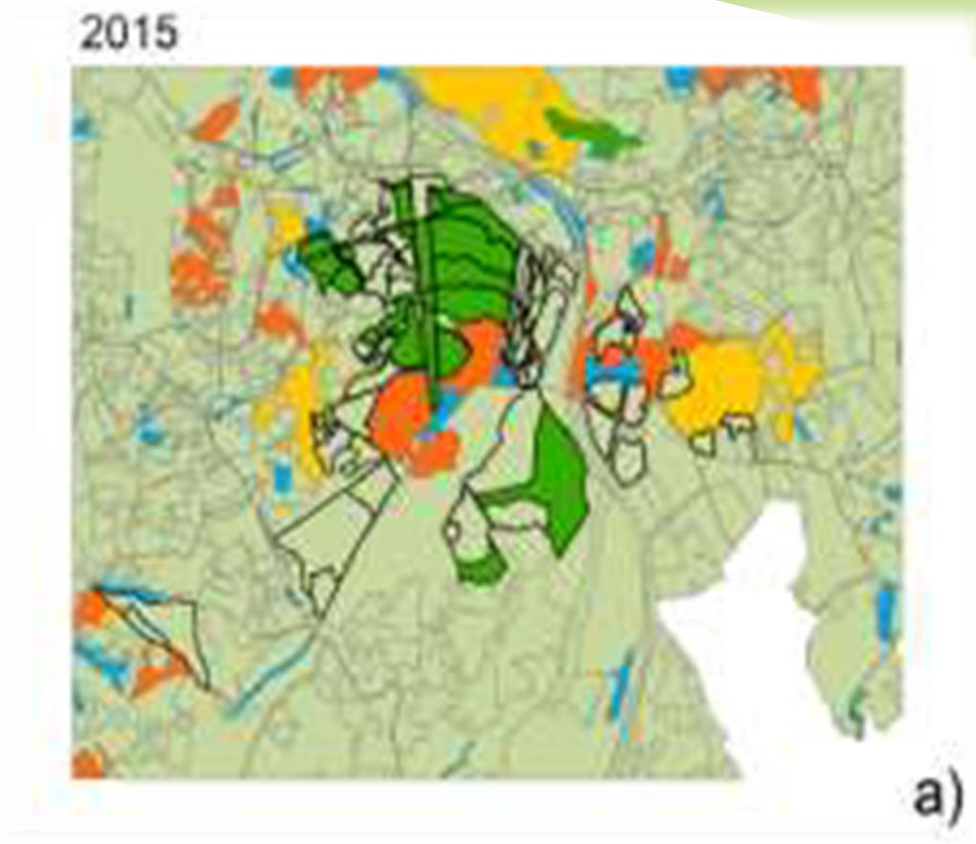


IV. OUTCOMES ANALYSES

NON- AGGREGATE

|Assessing strategic fuel location - 70 ha

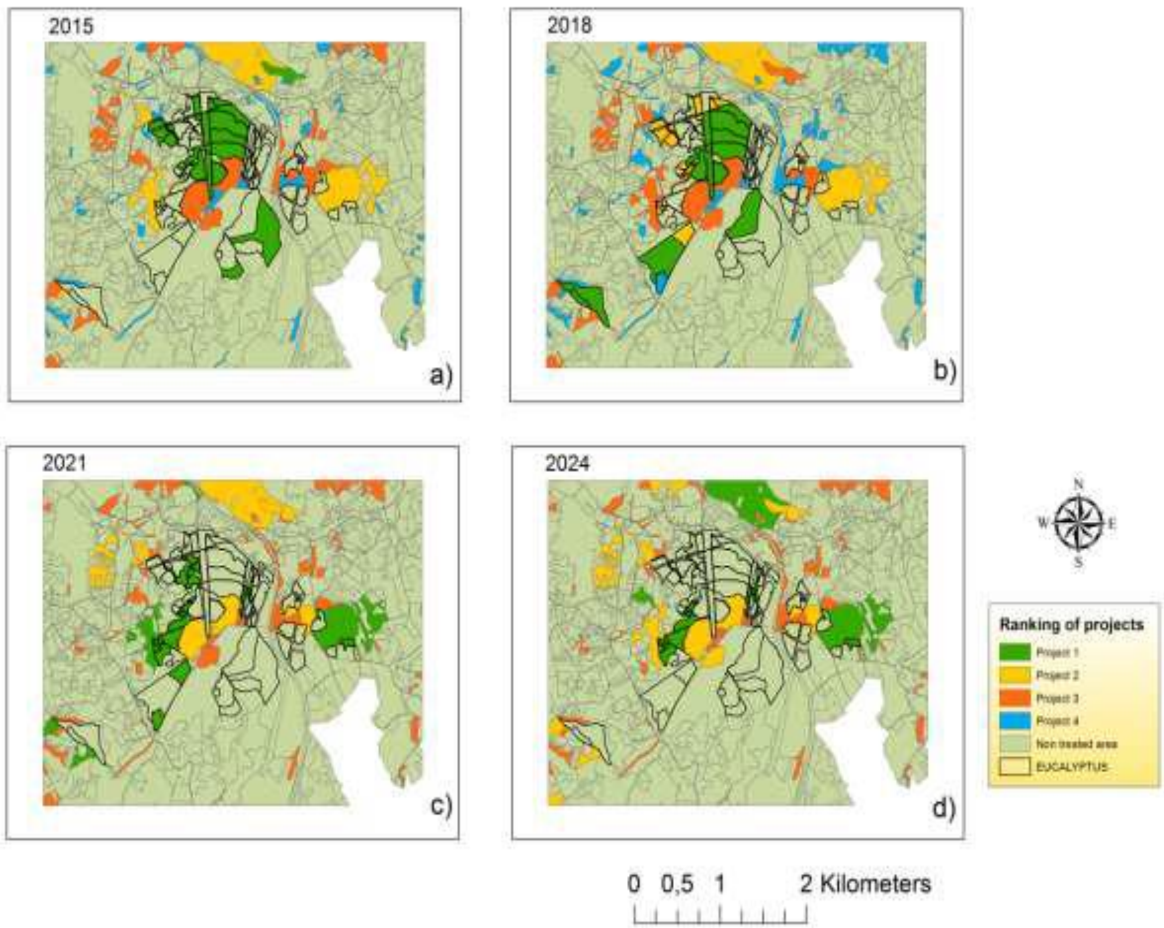
- Individual and independent fuel treatments strategy



IV. OUTCOMES ANALYSES

|Assessing strategic fuel location - 70 ha

NON- AGGREGATE



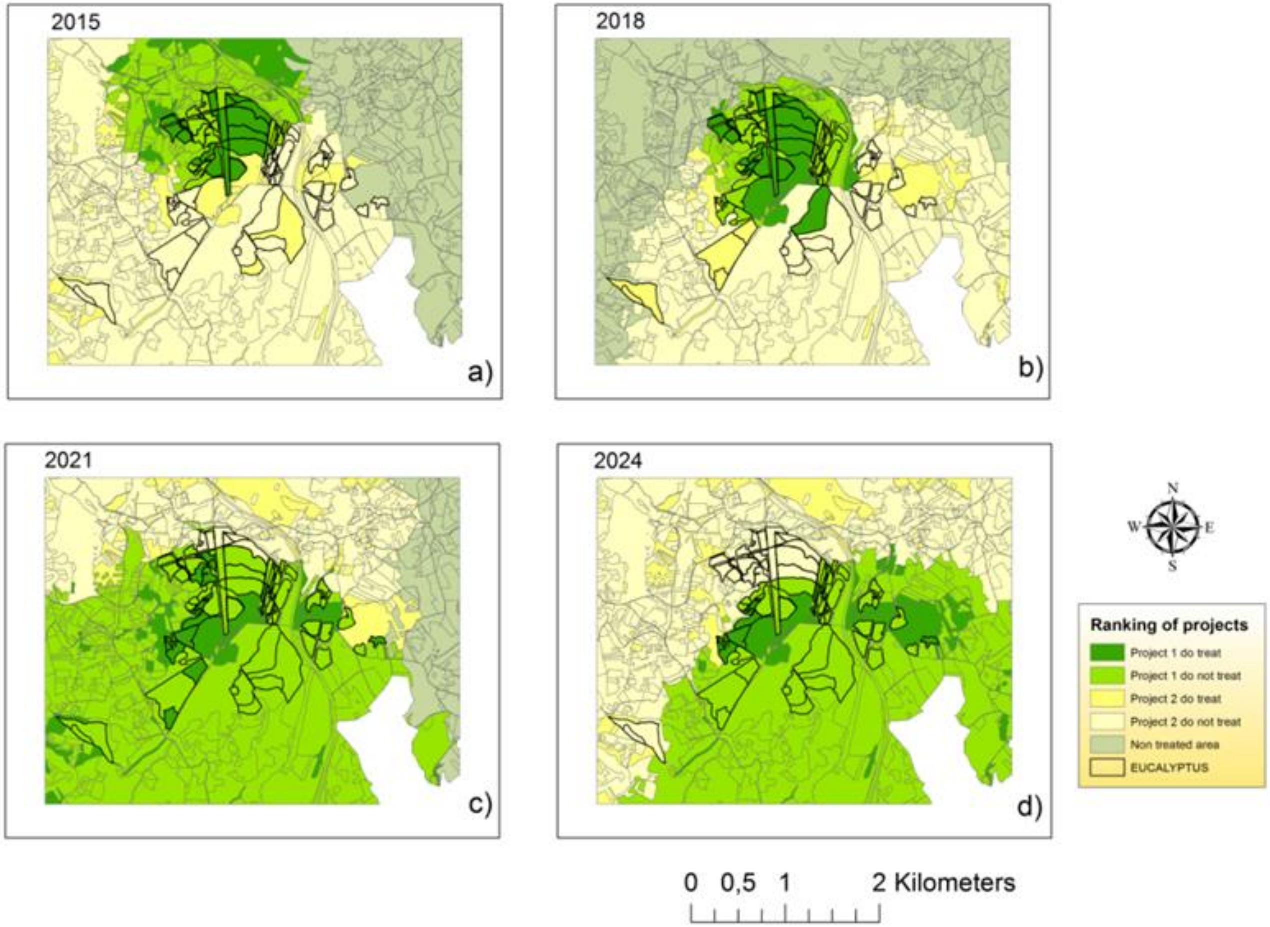
The higher pressure of fire behaviour in the earlier stages of the study period triggered most of the spatial fuel treatments within eucalypt plantations in a juvenile stage

Optimazing young plantations *vs* mature stands

IV. OUTCOMES ANALYSES

|Assessing strategic fuel location - 100 ha

AGGREGATE

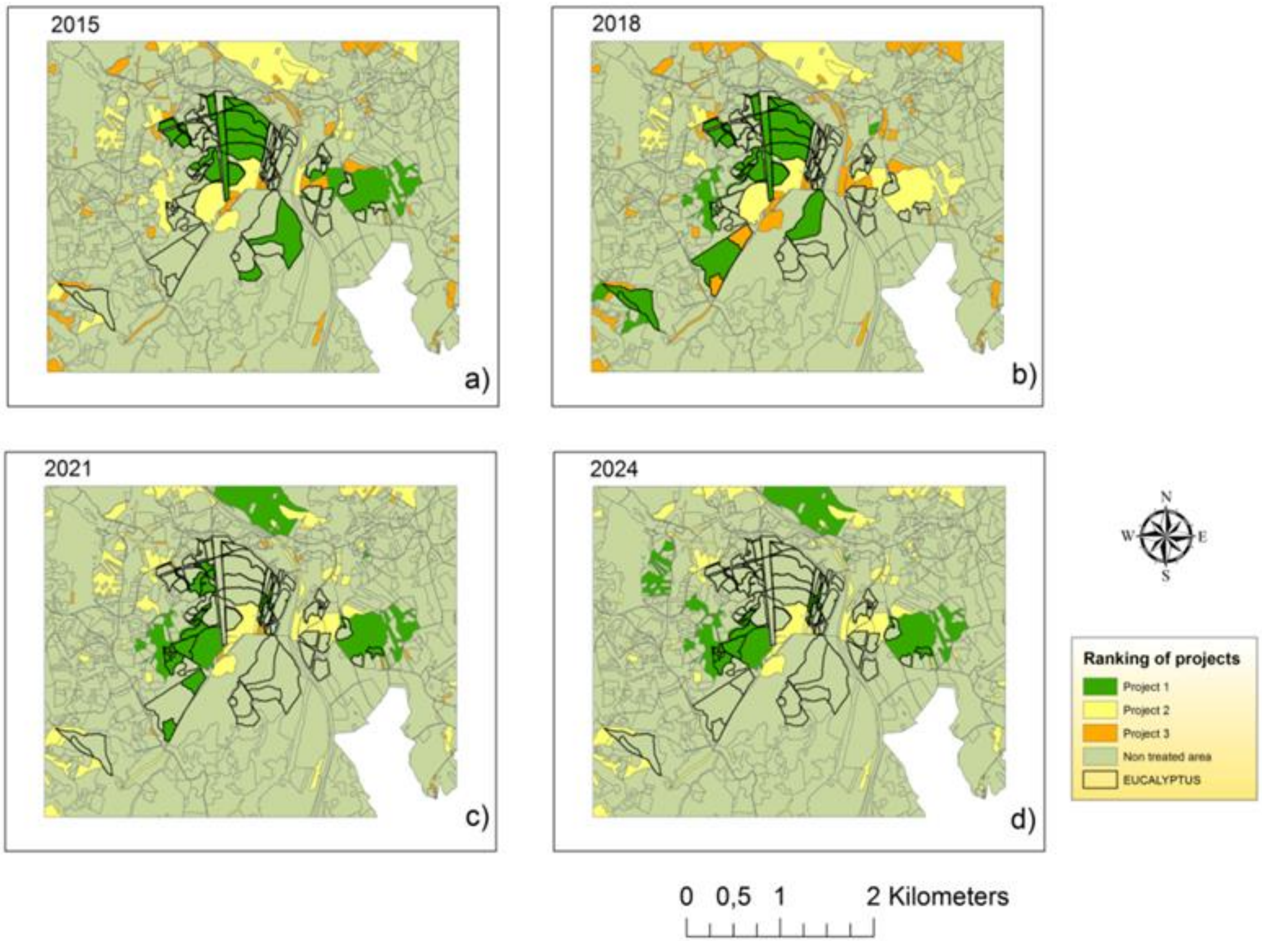


The number of available projects **decrease over time as fire metrics decreases over time** and do not surpass thresholds thus do no trigger fuel treatments operations

IV. OUTCOMES ANALYSES

|Assessing strategic fuel location - 100 ha

NON- AGGREGATE



The higher fire hazards belong to periods 2015 and 2018

In later stages of the study period fuel treatments included juvenile eucalypts but also shrublands areas

| *Some considerations*

V. CONSIDERATIONS

- ✓ The time-investing strategies in this work present an innovation for a **optimal fuel prevention management over time**, which is an insight into real-life problems in forest planning.

- ✓ The planning methodology might help **creating collaborative opportunities within landowners** for accomplishing objectives. Where should The Navigator Company invest on prevention? Which stands should be assumed for fire prevention treatment management?

- ✓ Forest management planning in commercial eucalypt plantations can **potentially accomplish multiple objectives such as augmenting profits and sustaining ecological assets while reducing wildfire risk at landscape scale**.

Take home message…

PREVENTIVE SILVICULTURAL PRACTICES!

VI. ACKNOWLEDGEMENT

* **The Navigator Company** for supplying the inventory databases and support in field visit
* **Project INTEGRAL** "Future Oriented Integrated Management of European Forest Lands, both funded by the European Union Seventh Framework Programme (FP7-PEOPLE-2010-IRSES
* SuFoRUn "Models and decision SUpport tools for integrated FOrest policy development under global change and associated Risk and Uncertainty" (FP7-PEOPLE-2009-IRSES)
* **Project FIRE-ENGINE** " Design Flexível de Sistemas de Gestão de Incêndios Florestais -" (MIT/FSE/0064/2009), financiado por fundos nacionais através da FCT/MCTES (PIDDAC) e co-financiado pelo Fundo Europeu de Desenvolvimento Regional (FEDER)

Gracias! Obrigada! Thank you!