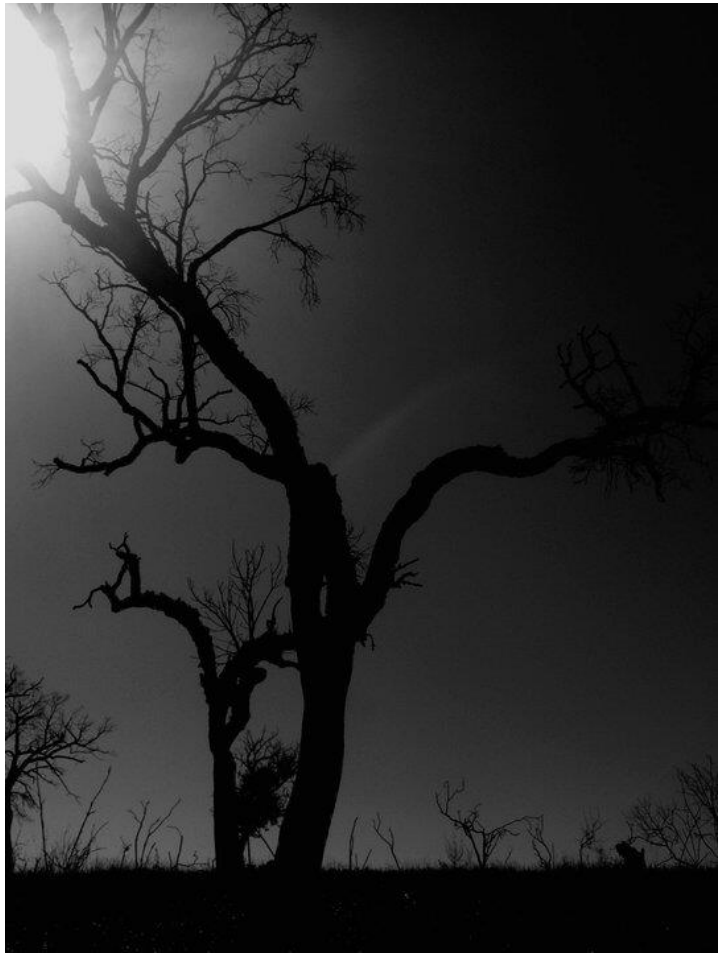


Landscape fire severity: a multi-scale analysis of the drivers

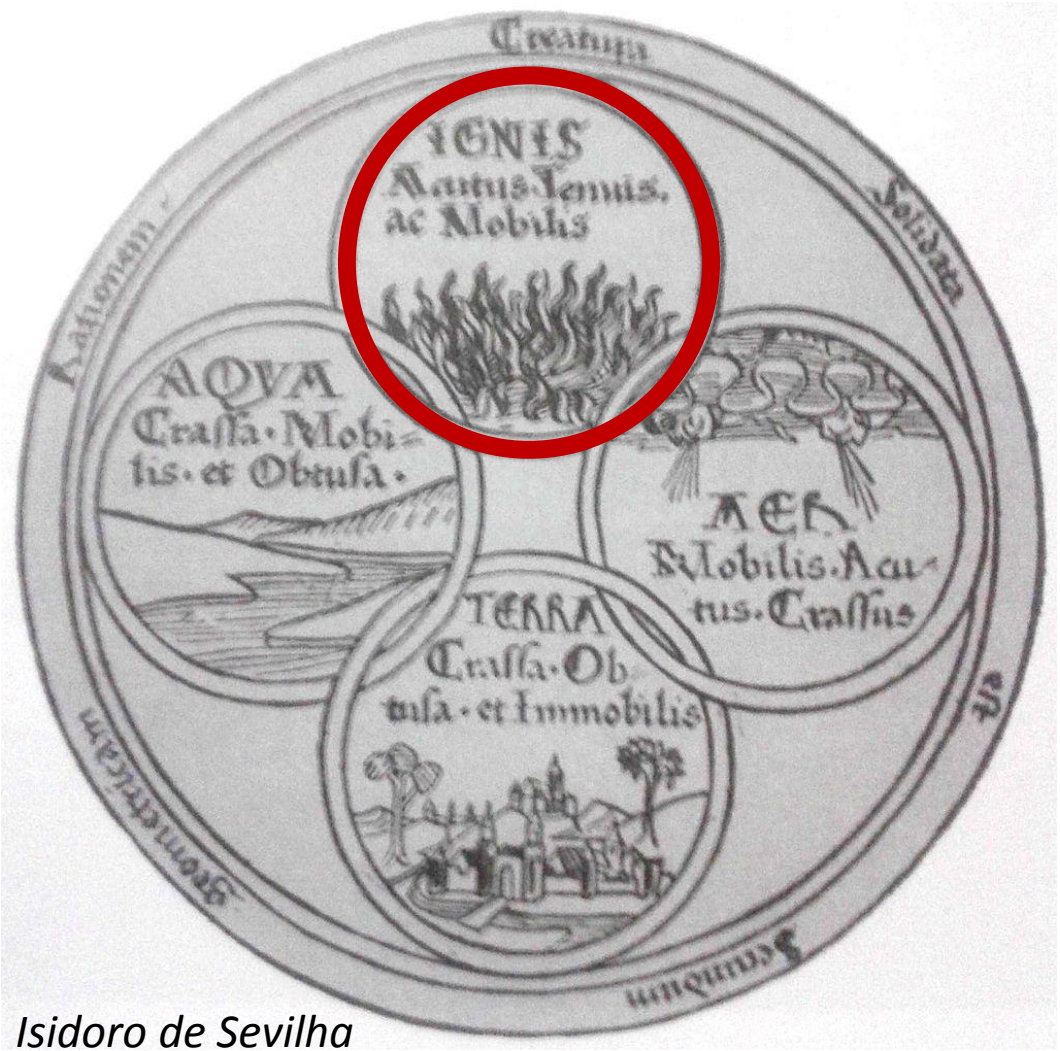
N. Guiomar,

S. Godinho, R. Machado, T. Marques, P. Fernandes

INTRODUCTION

Phyllirea angustifolia
(Juli Pausas)

Pinus pinaster (serotinous cones; Photo: K.B. Budde)



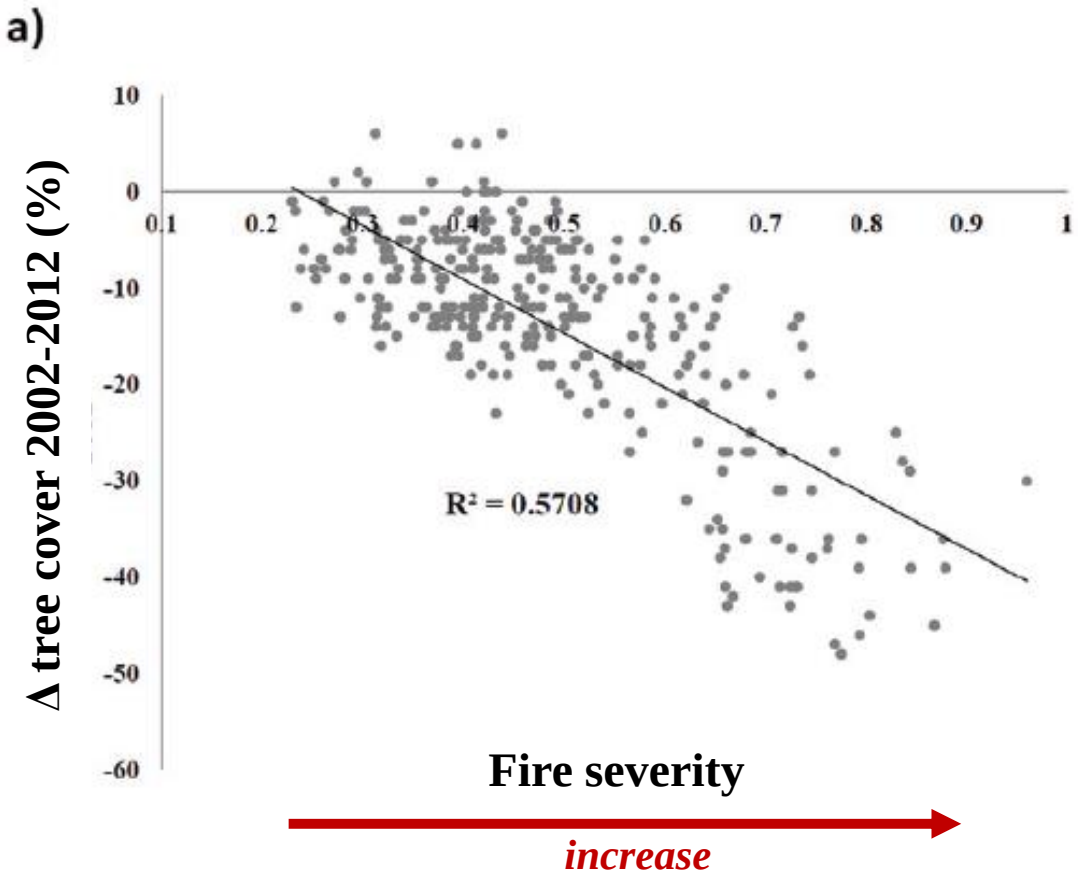
Isidoro de Sevilha

Quercus suber (epicormic regeneration + cork)

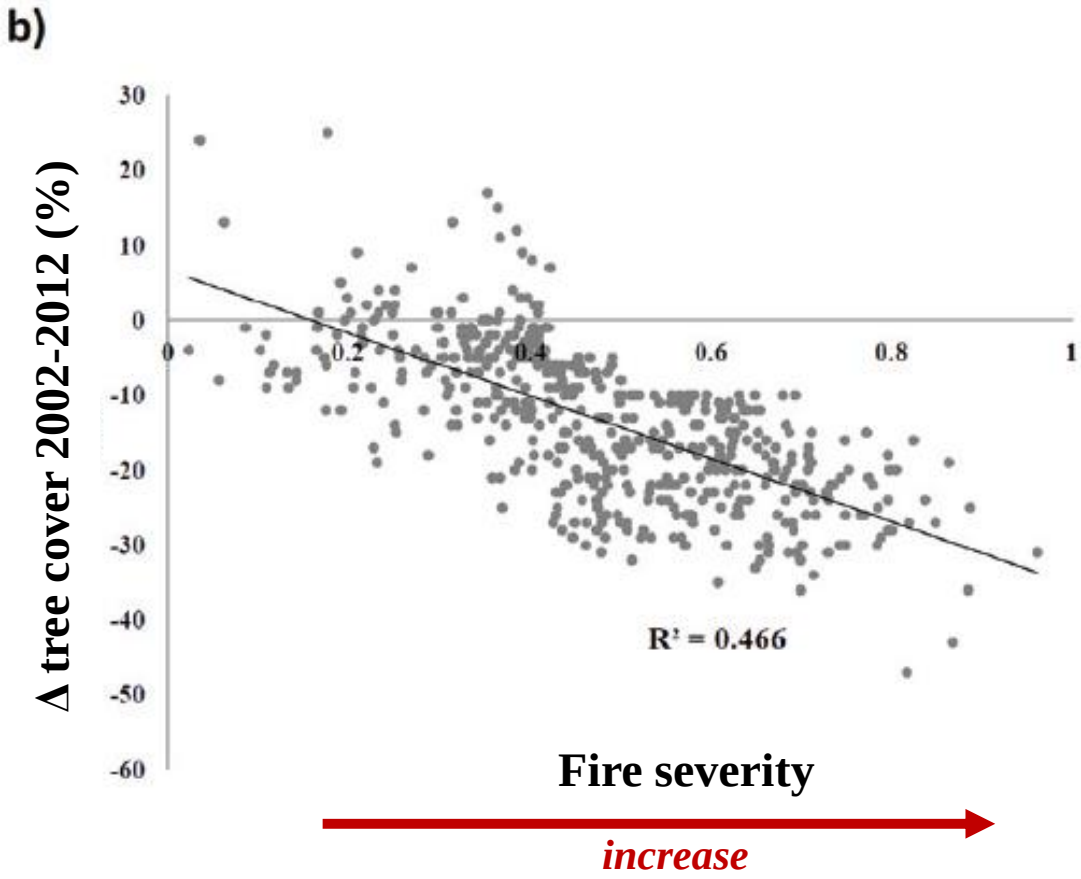
Cistus ladanifer (hard-coated seeds)

INTRODUCTION

Cork oak



Maritime pine



OS INCÊNDIOS COMO CAUSA DE DESARBORIZAÇÃO EM PORTUGAL

Por: Paulo Fernandes[1] e Nuno Guiomar[2]
[1]pfern@utad.pt
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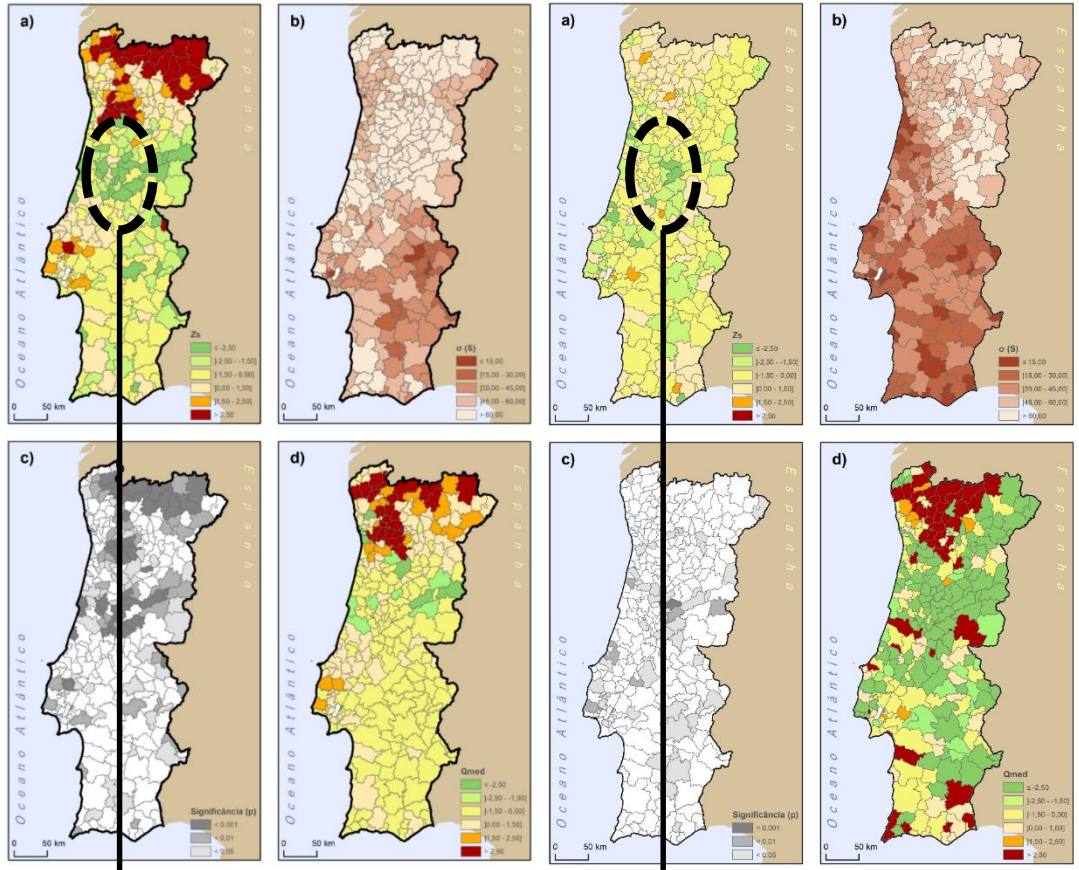
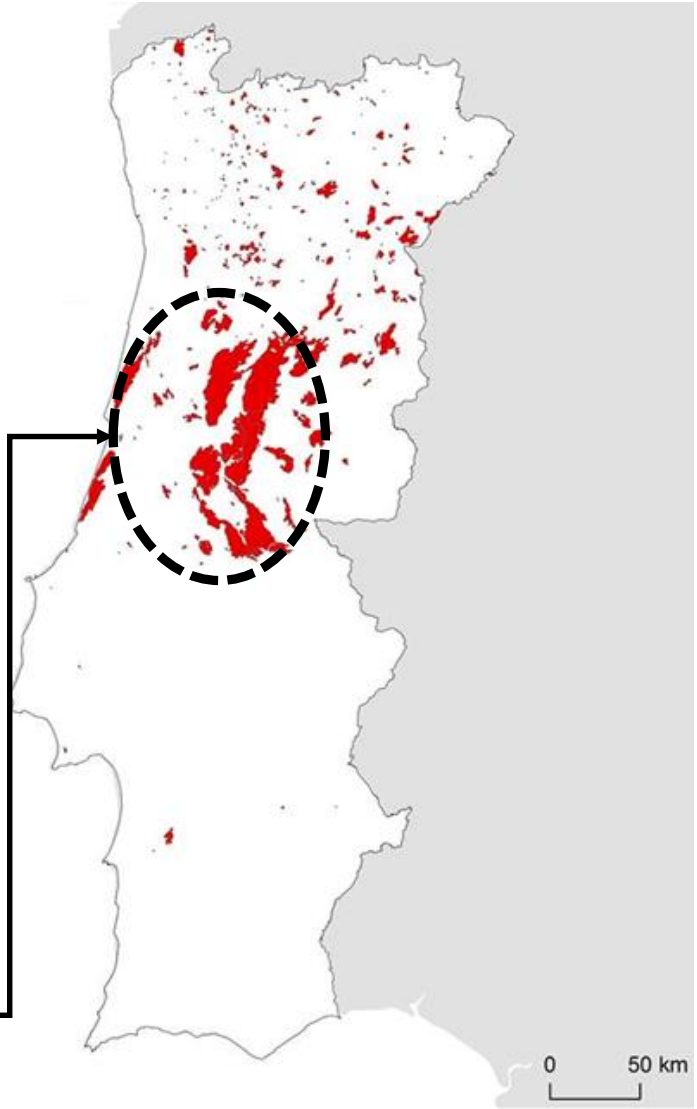
[1]Centro de Investigação e Tecnologias Agroambientais e Biológicas (CITAB), Universidade de Trás-os-Montes e Alto Douro
[2]Instituto de Ciências Agrárias e Ambientais Mediterrânicas (ICAAM), Universidade de Évora

INTRODUCTION

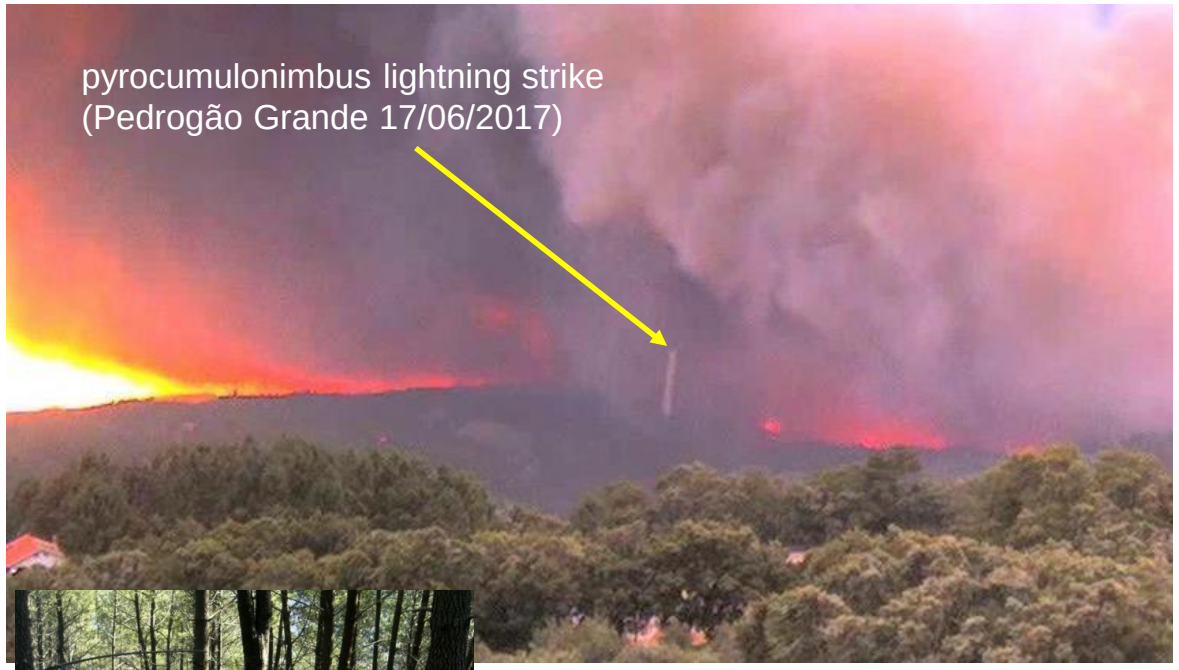


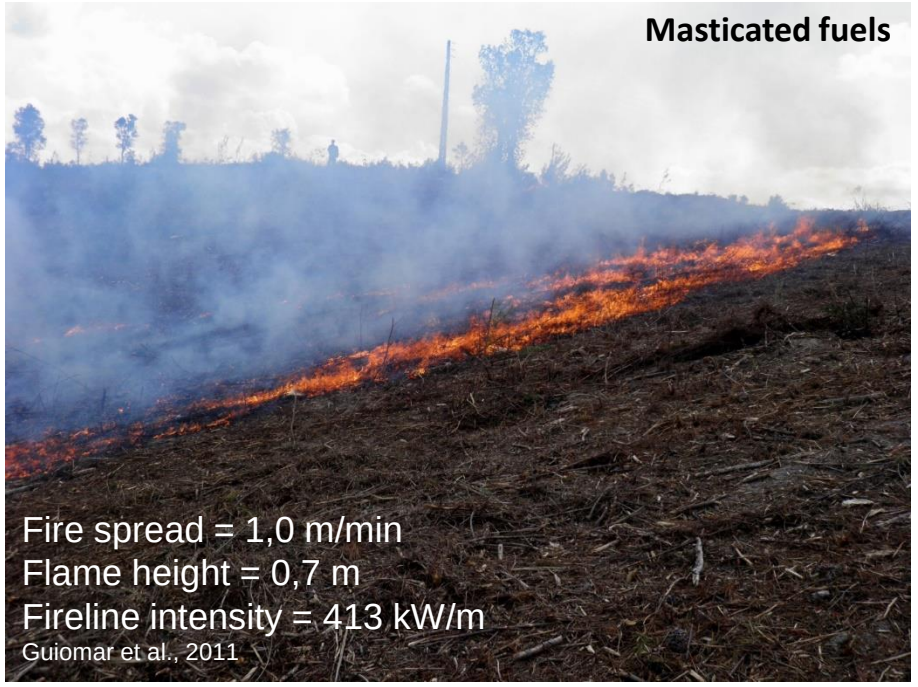
decrease in the number of ignitions and burnt area between 1980 and 2013

Mega-fires in 2017



INTRODUCTION





INTRODUCTION

*By definition, it is a direct measure of the effect of fire on the landscape/ecological system/**vegetation**/soil*

Fire severity assessment is one of the critical instruments for the necessary paradigm shift in fire management across fire-prone regions

PERSPECTIVE

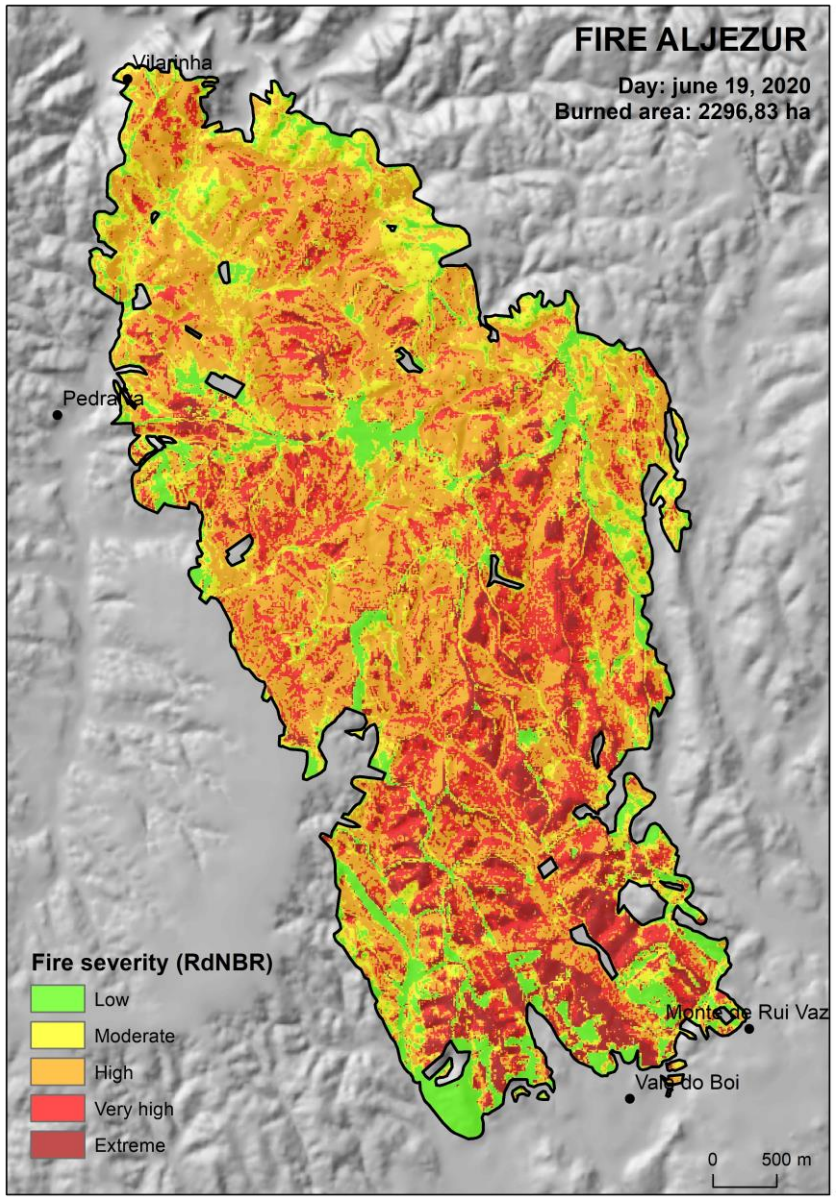
Wildfire management in Mediterranean-type regions: paradigm change needed

Francisco Moreira[1,2,24], Davide Ascoli[3], Hugh Safford[4], Mark A Adams[5], José M Moreno[6], José M C Pereira[7], Filipe X Catry[8], Juan Armesto[9], William Bond[10], Mauro E González[11], Thomas Curt[12], Nikos Koutsias[13], Lachlan McCaw[14], Owen Price[15], Juli G Pausas[16], Eric Rigolot[17], Scott Stephens[18], Cagatay Tavsanoglu[19], V Ramon Vallejo[20], Brian W Van Wilgen[21], Gavriil Xanthopoulos[22] and Paulo M Fernandes[23]

Set the need for a paradigm shift

*policy effectiveness should not be primarily measured as a function of area burned (as it usually is), but rather **as a function of avoided***

HOW CAN BE MEASURED?



Field work

Departamento Florestal
Universidade de Trás-os-Montes e Alto Douro

GUÍA PARA LA EVALUACIÓN DE CAMPO DE LA SEVERIDAD DEL FUEGO EN EL SUELO

• CRISTINA FERNÁNDEZ • JOSÉ M. FERNÁNDEZ-ALONSO
• JACOB KEIZER • ANTONIO GIRONA-GARCÍA

Centro de Investigación Forestal de Lourizán-Xunta de Galicia
Centre for Environmental and Marine Studies (CESAM),
Dept. Environment and Planning, University of Aveiro

Elaborado no âmbito do projecto de Norma Portuguesa "Sistemas de Gestão Florestal Sustentável. Aplicação dos critérios pan-europeus para a gestão florestal sustentável"

Critério 2. – Manutenção da saúde e vitalidade dos ecossistemas florestais
Quadro B.4 – Indicador 2.1: Perigo de incêndio

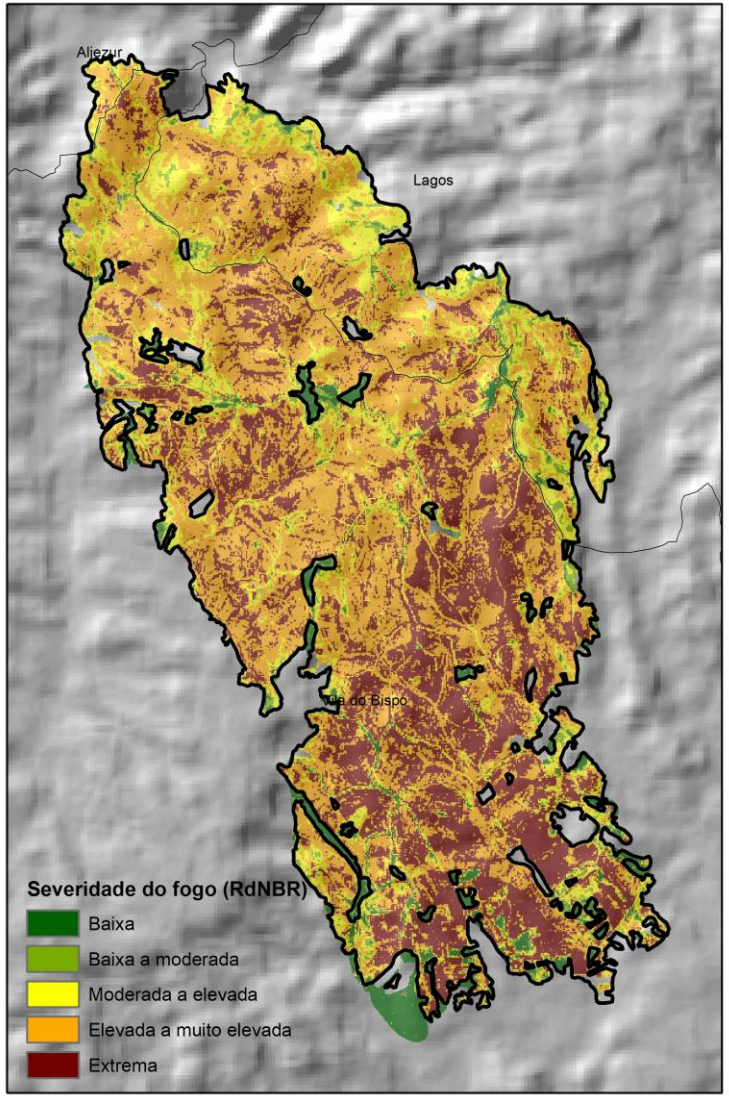
Through satellite images

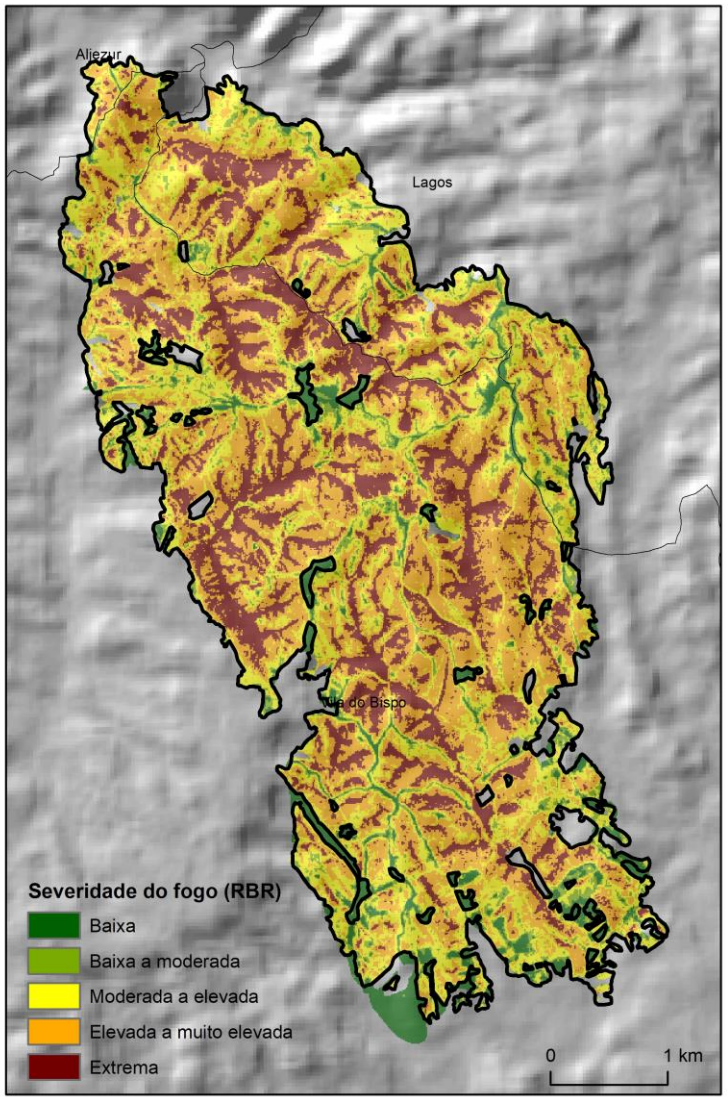
$$dNBR = \left(\left(NBR_{prefire} - NBR_{postfire} \right) * 1000 \right)$$

$$NBR = \left(\frac{band\ 4 - band\ 7}{band\ 4 + band\ 7} \right)^{*}$$

So what prevents the transition from models that inform fire managers of the higher or lower probability of a given area being affected by a fire to models that indicate how it will potentially burn?

WHAT IS THE BEST METRIC?



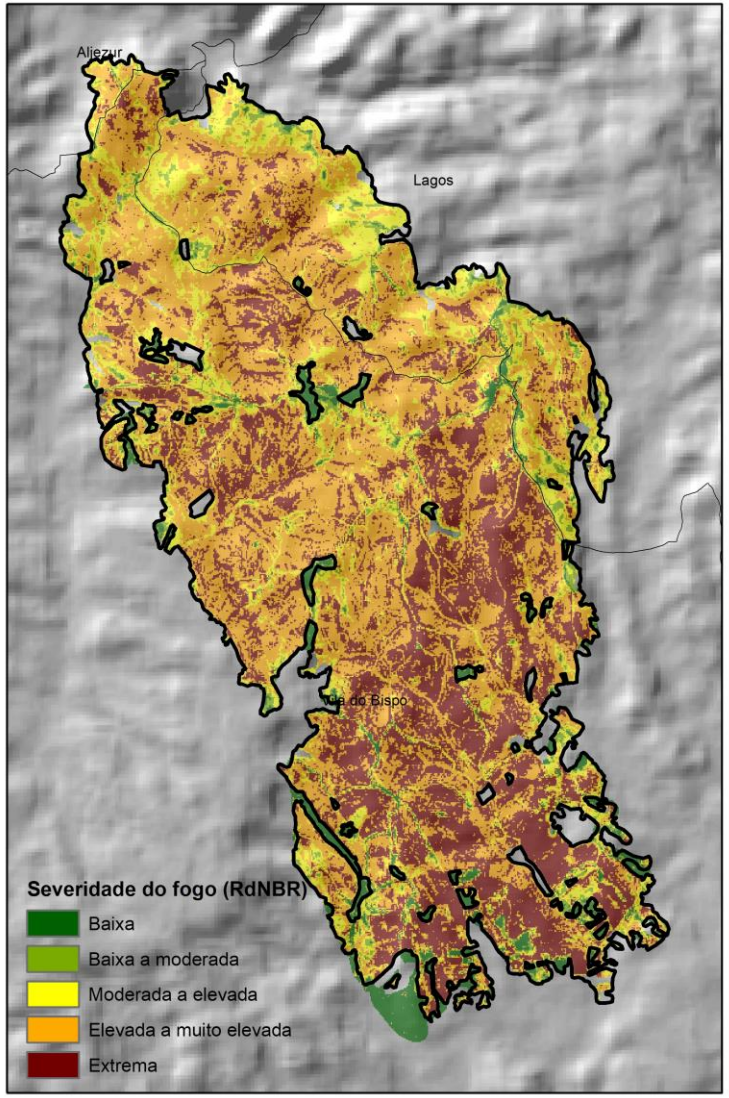


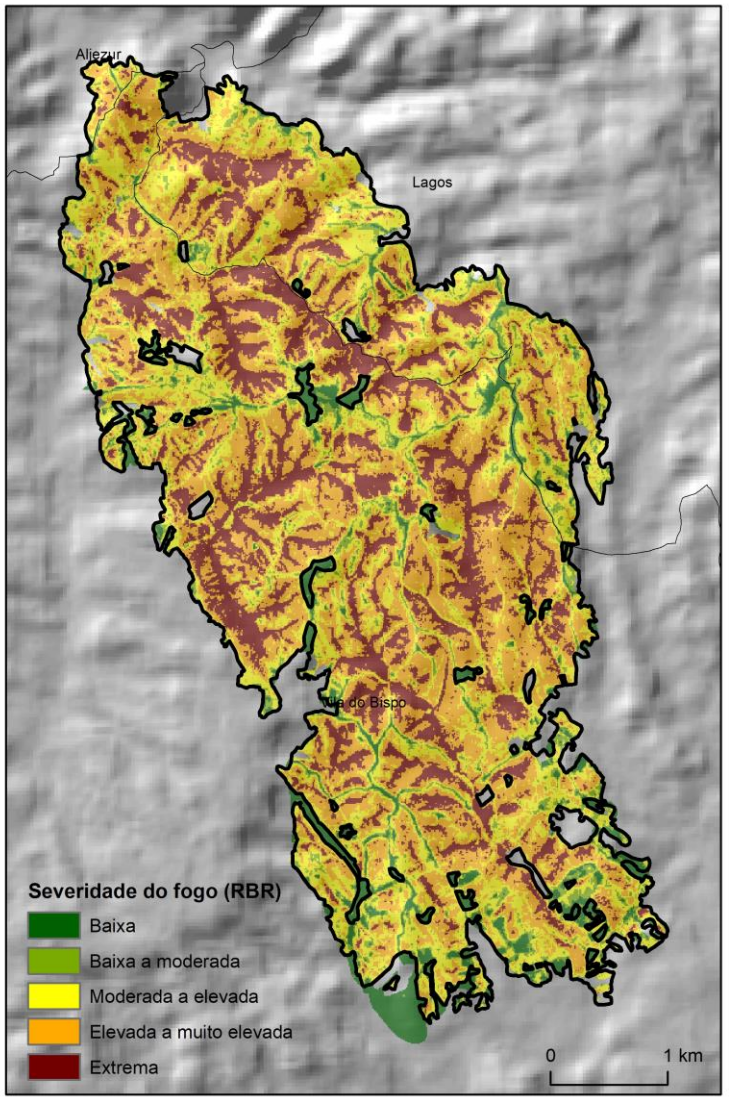
References	Post-fire metrics tested	Vegetation types/Regions
Harris et al., 2011	NDVI, SAVI, NBR, GEMI, VI_3, MSAVI, $GEMI_3$, MIRBI, BAI, EVI, CSI	Chaparral
Schepers et al., 2014	NDVI, SAVI, NBR, GEMI, MSAVI, MIRBI, BAI, EVI, CSI	Central European temperate heathlands
Fernández-Manso *et al*., 2016	NDVI, NBR, GNDVI, SR, DVI, $NDVI_{re1-3n}$, $NDVI_{re1-3}$, PSRI, CI_{re}, ND_{re1-2}, ND_{re1-2m}, SR_{re1-2}, MSR_{re}, MSR_{ren}	Forest stands of *Pinus pinaster* and *Quercus pyrenaica*
Navarro et al., 2017	NDVI, GNDVI, $NDVI_{re1-3n}$, NBR	Macaronesia
Santana et al., 2018	NDVI, NBR, GEMI, MIRBI, NBR_2, BAIM (+ individual bands with and without “zero mean” normalization)	Amazonia
Chen *et al*., 2020	GEMI, NBR, SAVI, MSAVI, GNDVI, NDVI, BAI (+ principal components, and NIR band)	Tundra
van Dijk et al. 2021	NDVI, SAVI, NBR (with $SWIR_1$ and $SWIR_2$), MSAVI, MIRBI, BAI, EVI, NBR_2, BAIM, $BAIS_2$	Heterogeneous socio-ecological systems

Or through a bi-temporal approach

$$\mathrm{dNBR} = \left(\left(\mathrm{NBR}_{\mathrm{prefire}} - \mathrm{NBR}_{\mathrm{postfire}}\right) * 1000\right)$$

WHAT IS THE BEST METRIC?





Severity Level	dNBR Range (scaled by 10^3)	dNBR Range (not scaled)
Enhanced Regrowth, high (post-fire)	-500 to -251	-0.500 to -0.251
Enhanced Regrowth, low (post-fire)	-250 to -101	-0.250 to -0.101
Unburned	-100 to +99	-0.100 to +0.99
Low Severity	+100 to +269	+0.100 to +0.269
Moderate-low Severity	+270 to +439	+0.270 to +0.439
Miderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

Estudios	Índice	Umbrales de clasificación a partir de teledetección		
		No quemado-Baja	Baja-Moderada	Moderada-Alta
(Key and Benson, 2006)	dNBR	100	270	440
(Miller and Thode, 2007)	dNBR	41	177	367
(Cansler and McKenzie, 2012)	dNBR	106	218	456
(Parks *et al.*, 2014)	dNBR	42	180	422
Este estudio	dNBR	160	260	481
(Miller and Thode, 2007)	RdNBR	69	316	641
(Cansler and McKenzie, 2012)	RdNBR	189	372	703
(Parks *et al.*, 2014)	RdNBR	99	319	704
Este estudio	RdNBR	230	475	835
(Parks *et al.*, 2014)	RBR	35	130	298
Este estudio	RBR	105	200	355

Different contexts → Different thresholds to define fire severity classes

Estudio de la severidad post-incendio en la Comunidad Valenciana comparando los índices dNBR, RdNBR y RBR a partir de imágenes Landsat 8

Botella-Martínez, M. A.*[1], Fernández-Manso, A.[2]

HOW TO CALCULATE IT?

Moreover, dNBR values may have a high correlation with pre-fire NBR…

Miller & Thode, 2007

$$RdNBR = \frac{dNBR}{\left|NBR_{prefire}\right|^{0.5}}$$

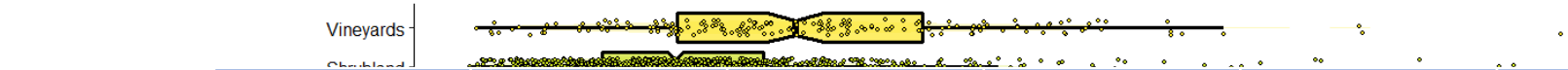
$$RBR = \left(\frac{dNBR}{(NBR_{prefire} + 1.001)}\right)$$

Parks et al., 2014

Just as the effects resulting from phenological dynamics must be reduced

$$dNBR = \left((NBR_{prefire} - NBR_{postfire}) * 1000\right) - dNBR_{offset}$$

However, in heterogeneous landscapes multiple offsets are needed (Guiomar et al., …)



	Mean	Mean SE	Median	Median SE	Mest	Mest SE
Annual crops	0.118	0.0018	0.114	0.0018	0.115	0.0019
Olive groves	0.106	0.0013	0.103	0.0012	0.103	0.0014
Vineyards	0.092	0.0036	0.088	0.0044	0.089	0.0037
Orchards	0.096	0.0075	0.080	0.0077	0.090	0.0082
Small-scale farming systems	0.081	0.0009	0.077	0.0010	0.078	0.0008
Pastures	0.110	0.0040	0.099	0.0048	0.104	0.0042
Deciduous oaks and Castanea sativa	0.053	0.0012	0.051	0.0015	0.051	0.0012
Eucalypt	0.029	0.0008	0.022	0.0007	0.025	0.0006
Other broadleaved forest	0.046	0.0009	0.041	0.0011	0.043	0.0008
Maritime pine	0.041	0.0006	0.037	0.0006	0.038	0.0005
Other coniferous forest	0.049	0.0036	0.046	0.0026	0.046	0.0029
Riparian vegetation	0.113	0.0183	0.080	0.0324	0.100	0.0227
Shrubland	0.062	0.0012	0.055	0.0013	0.057	0.0011
Artificial surfaces	0.049	0.0014	0.044	0.0013	0.046	0.0012

FIRE SEVERITY vs. FIRE SIZE

CSIRO PUBLISHING
www.publish.csiro.au/journals/ijwf *International Journal of Wildland Fire*, 2007, **16**, 277–284

Analysis of Alaskan burn severity patterns using remotely sensed data

Paul A. Duffy[A,E], *Justin Epting*[B], *Jonathan M. Graham*[C], *T. Scott Rupp*[A] and *A. David McGuire*[D]

Large fires are more likely to contain areas that are more severely burned than smaller fires as opposed to a uniform increase in overall burn severity.

(…) found a positive relationship between fire size and proportion of high fire severity, which was mediated by distinct fire behavior drivers involving direct and indirect pathways.

Science of the Total Environment 875 (2023) 162575

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Characterization of biophysical contexts leading to severe wildfires in Portugal and their environmental controls

José Manuel Fernández-Guisuraga [a,b,*], Samuel Martins [c], Paulo M. Fernandes [a]

Science of the Total Environment 536 (2015) 338–352

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

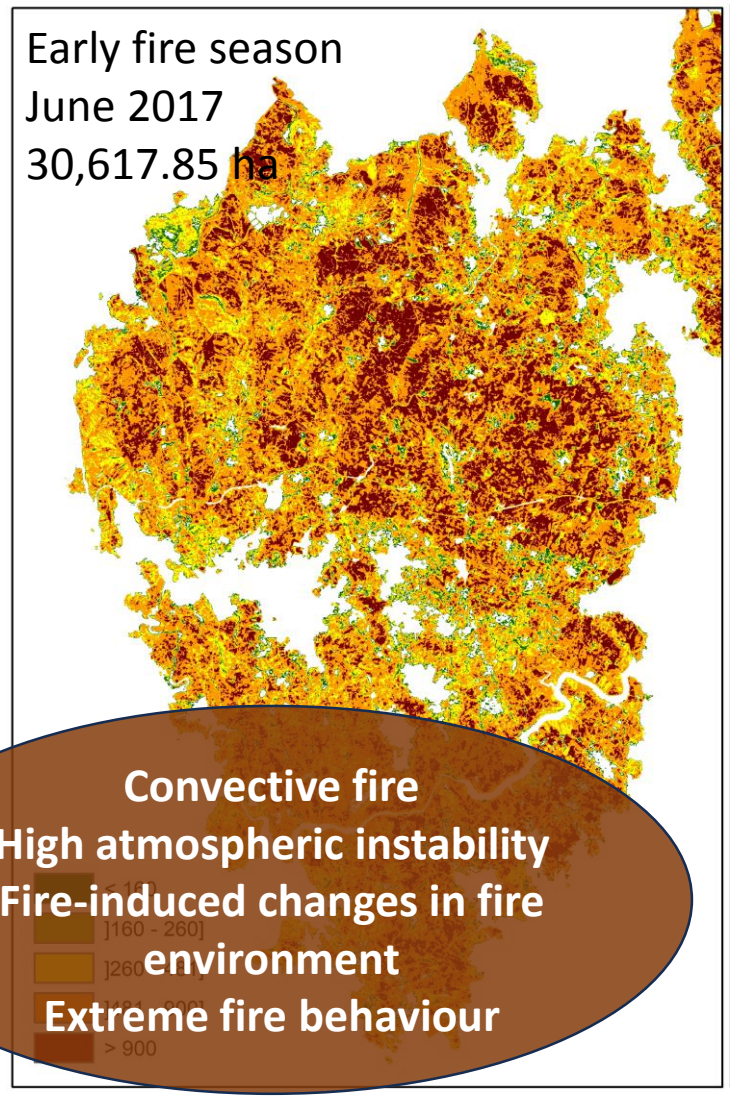
Wildfire patterns and landscape changes in Mediterranean oak woodlands

N. Guiomar [a,b,*], S. Godinho [a,b], P.M. Fernandes [c,d], R. Machado [a,b], N. Neves [b,e], J.P. Fernandes [a,b]

Large fires can affect montado resilience both directly and indirectly, contributing to its progressive decline. The authors highlight *the role of fire extent as a proxy of burn severity*.

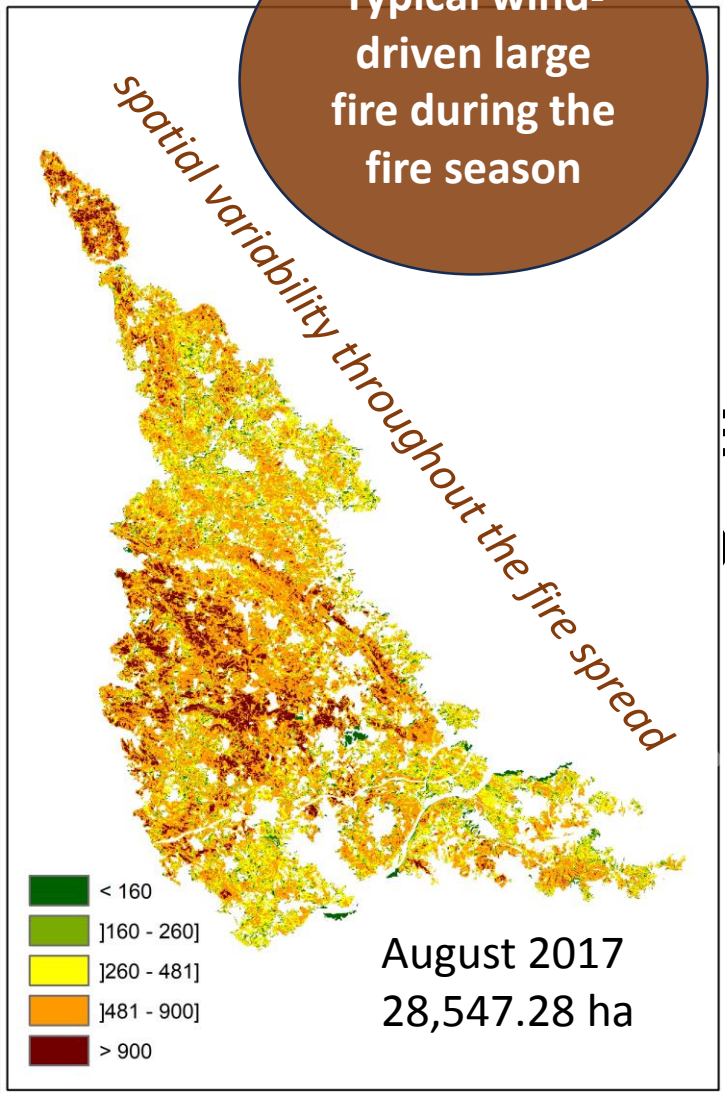
@ LANDSCAPE SCALE

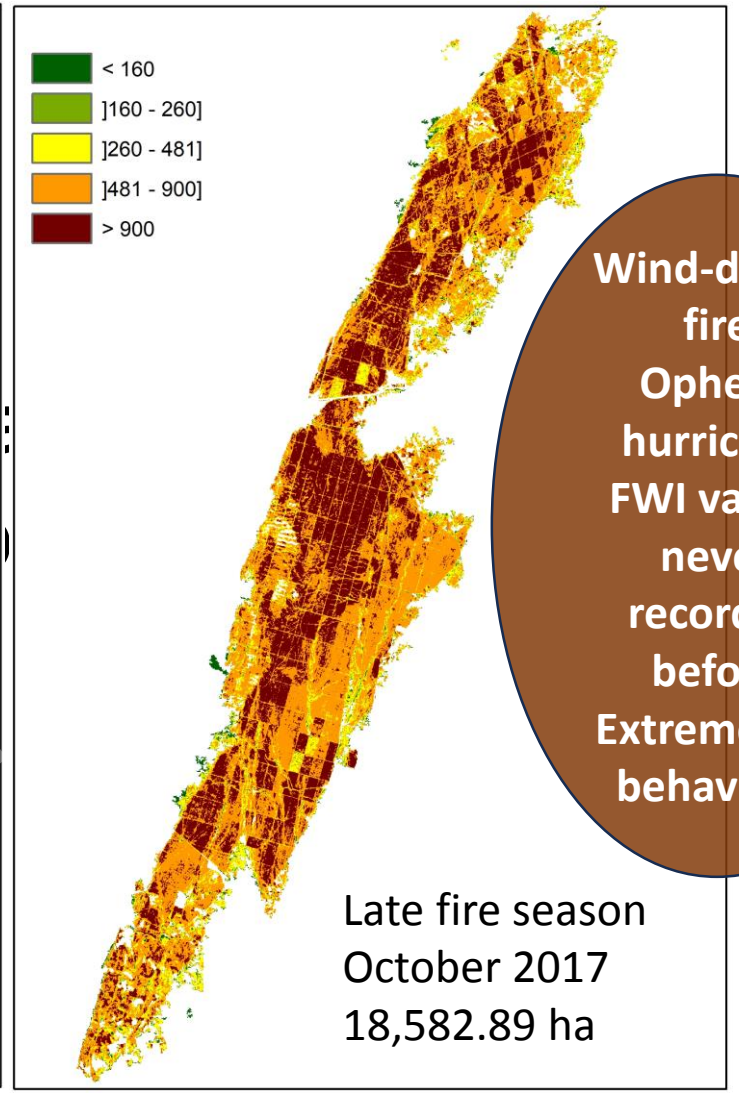
Variability between fires



Convective fire
High atmospheric instability
Fire-induced changes in fire environment
Extreme fire behaviour

Typical wind-driven large fire during the fire season

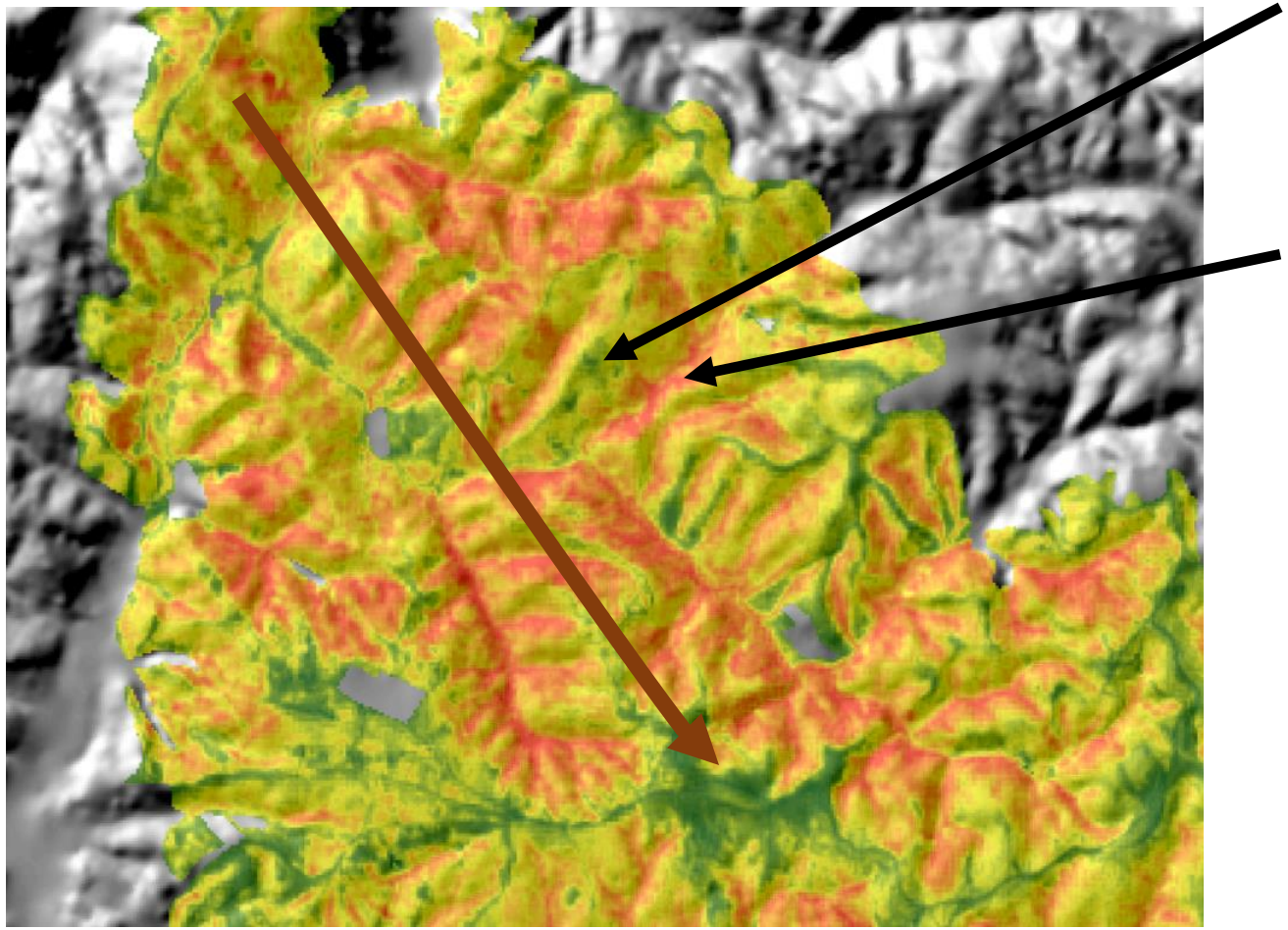




Wind-driven fire
Ophelia hurricane
FWI values never recorded before
Extreme fire behaviour

@ LANDSCAPE SCALE

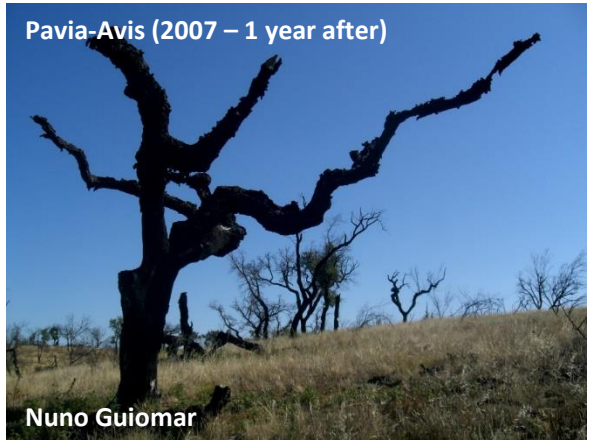
Variability between fires

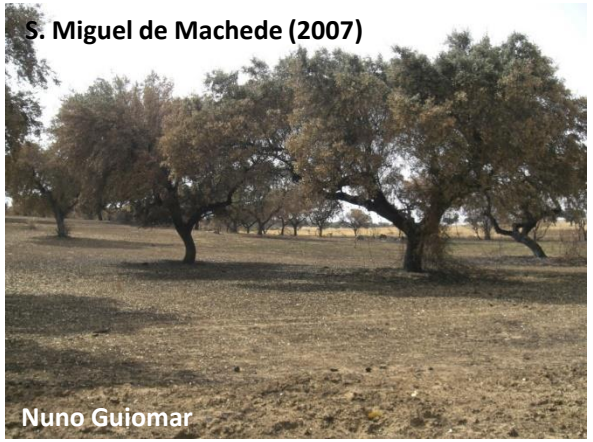


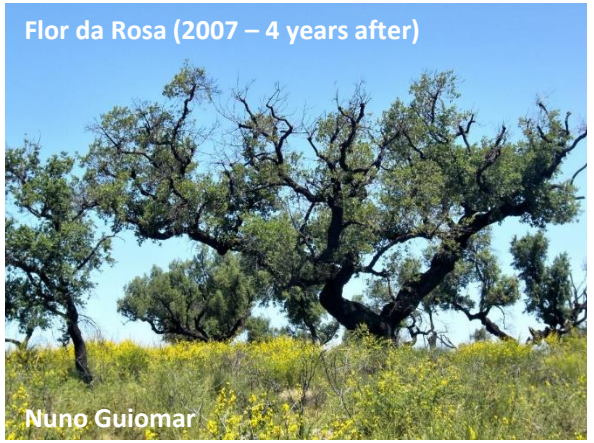
While variability in fire severity patterns between large fires are determined by macro- and/or meso-scale conditions, for fires driven by fire-weather more favorable to fire suppression, the spatial variability of fire severity is more related to local-scale parameters (e.g. "functional slope")

@ CLASS SCALE

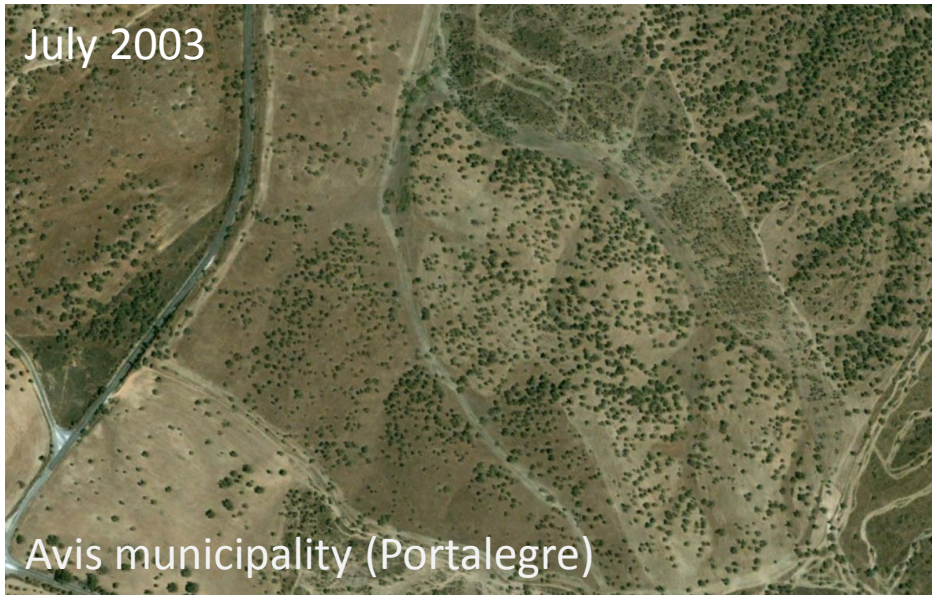
Variability within the same fuel types





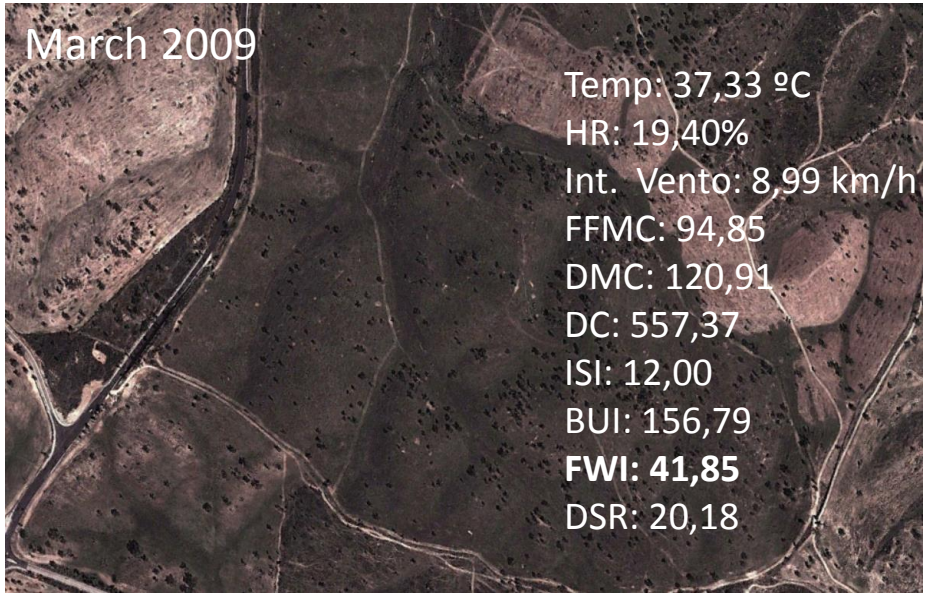


@ CLASS SCALE

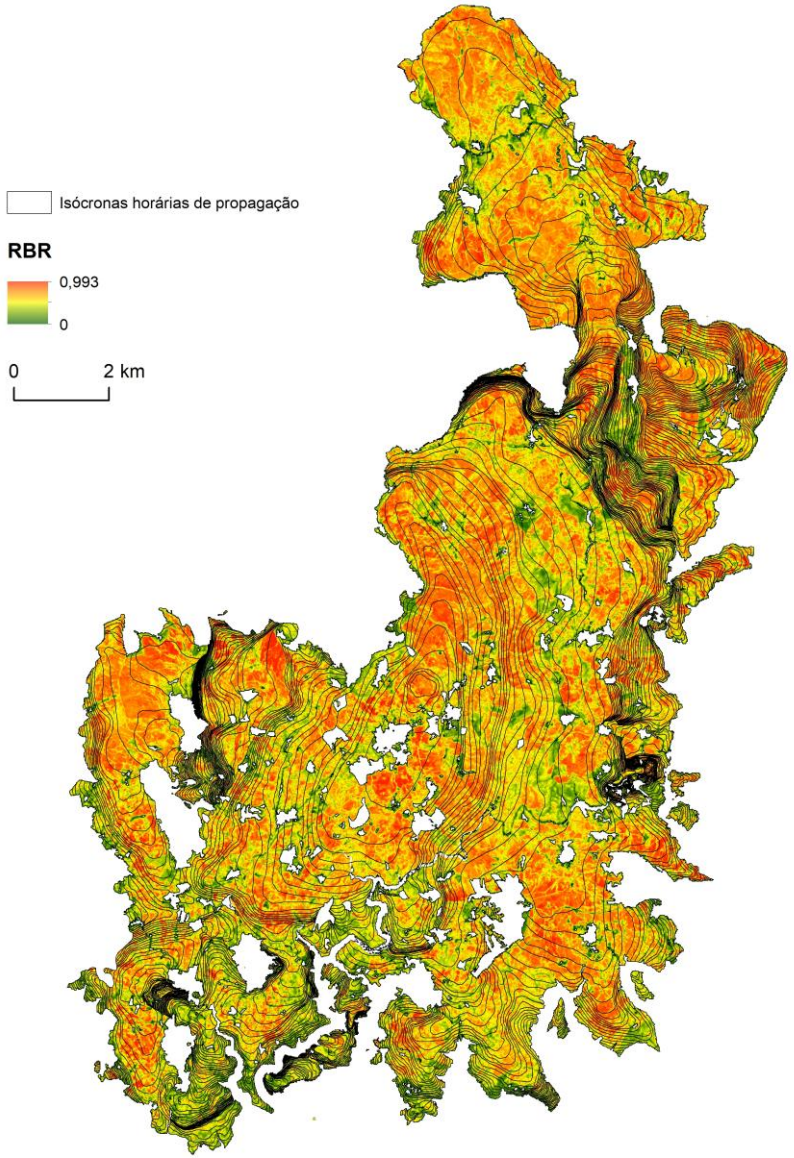

July 2003
Avis municipality (Portalegre)

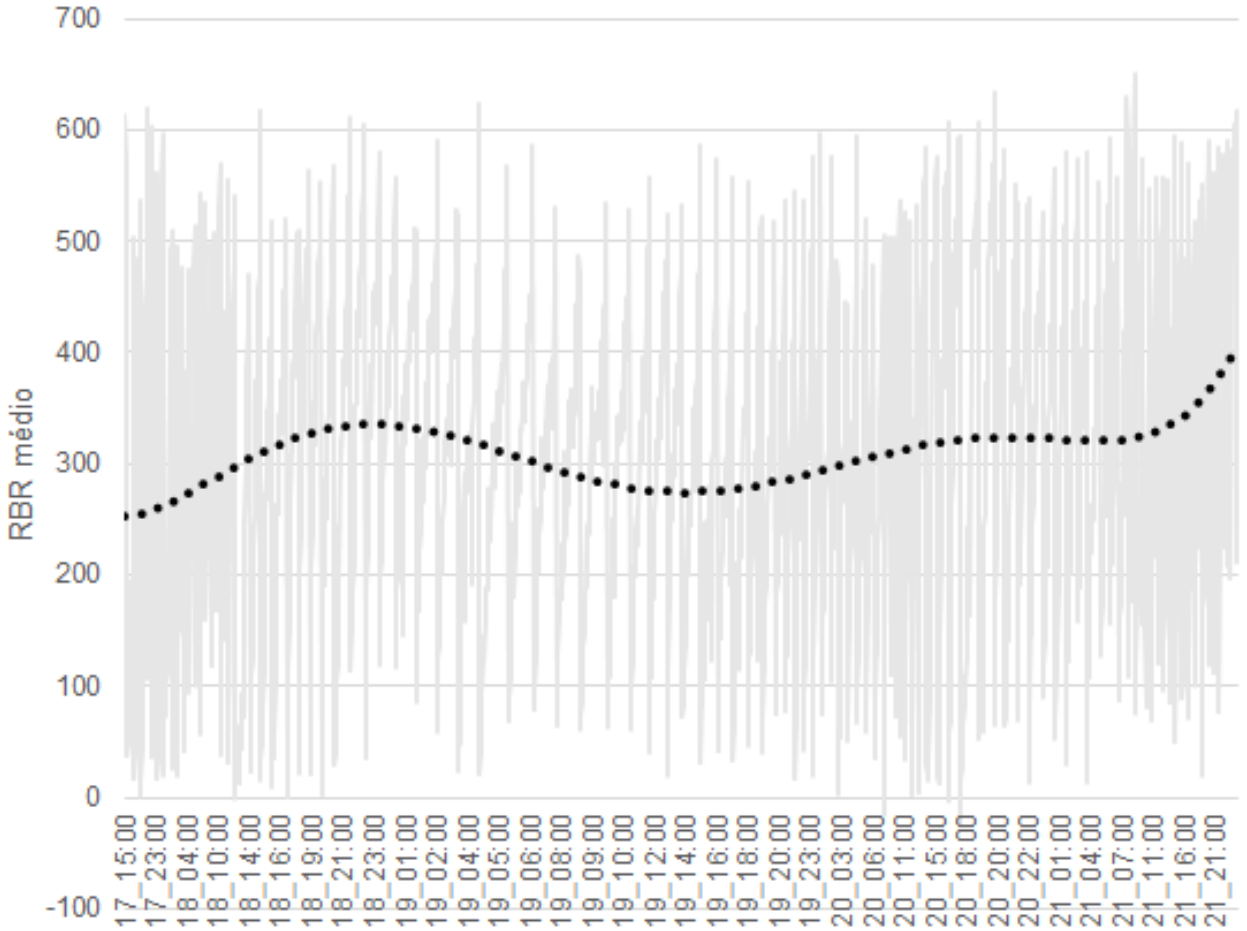

March 2021


August 2006
11/7/2006, 15:10
12/7/2006, 05:45
Total: 286 ha

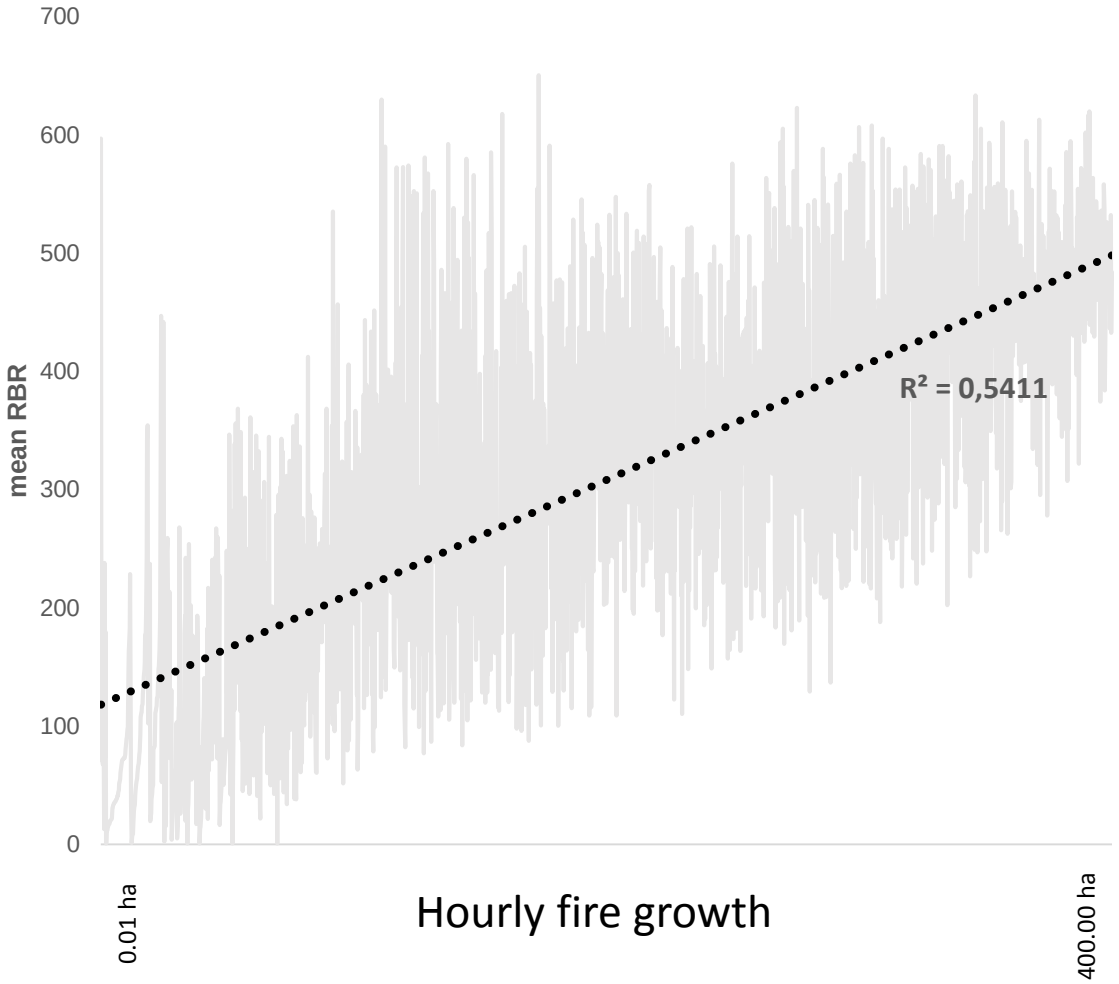

March 2009
Temp: 37,33 ºC
HR: 19,40%
Int. Vento: 8,99 km/h
FFMC: 94,85
DMC: 120,91
DC: 557,37
ISI: 12,00
BUI: 156,79
FWI: 41,85
DSR: 20,18

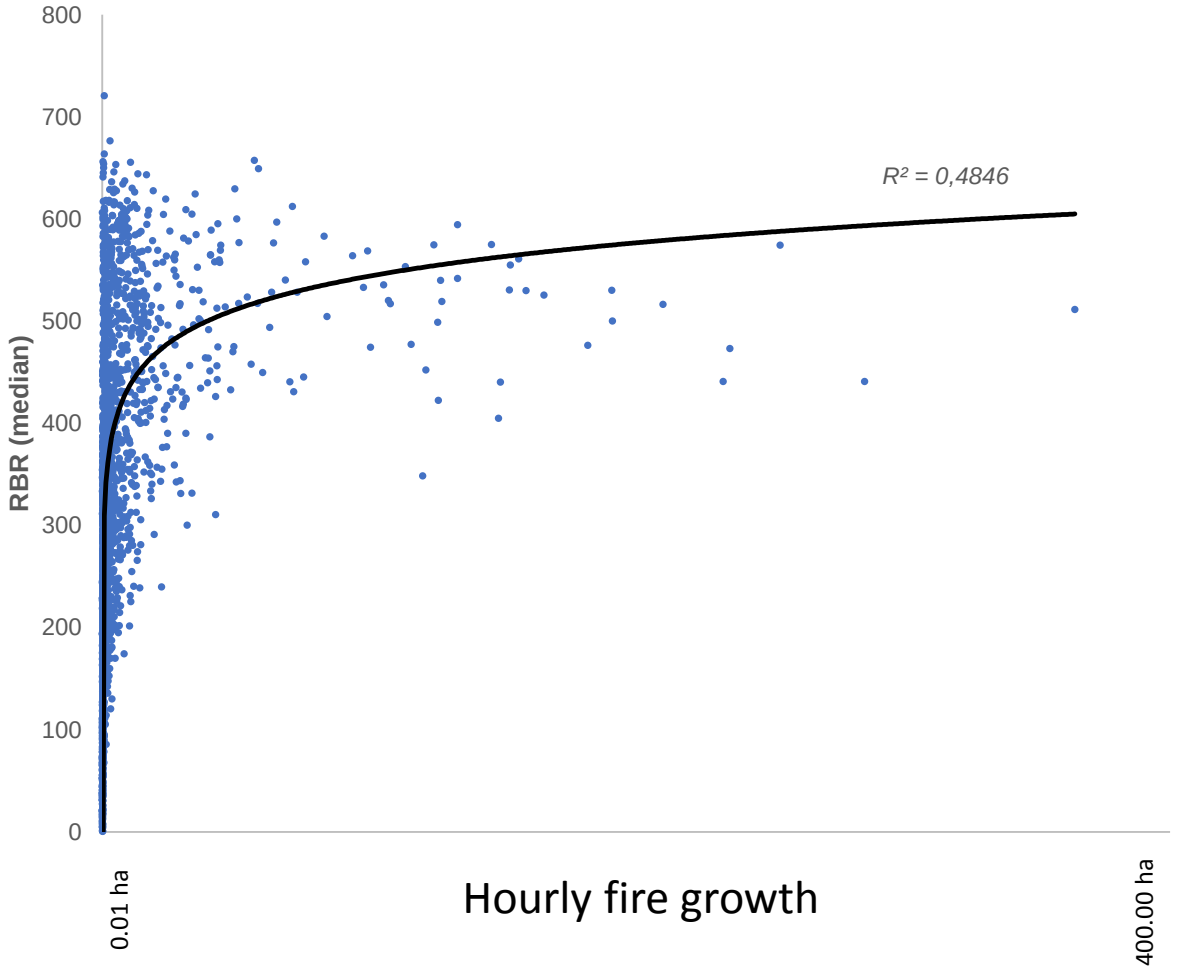
@ CLASS SCALE


Isócronas horárias de propagação
RBR
0,993
0
0
2 km

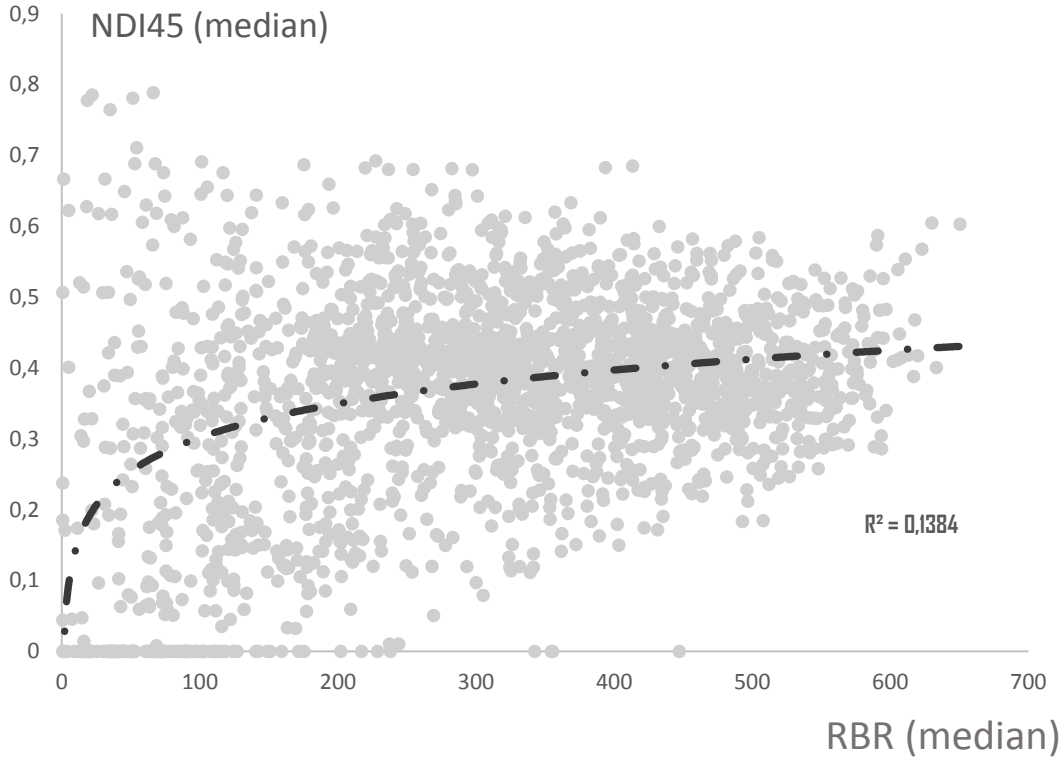

RBR médio
700
600
500
400
300
200
100
0
-100
17_15:00
17_23:00
18_04:00
18_10:00
18_14:00
18_16:00
18_19:00
18_21:00
18_23:00
19_01:00
19_02:00
19_04:00
19_05:00
19_06:00
19_08:00
19_09:00
19_10:00
19_12:00
19_14:00
19_16:00
19_18:00
19_20:00
19_23:00
20_03:00
20_06:00
20_11:00
20_15:00
20_18:00
20_20:00
20_22:00
21_01:00
21_04:00
21_07:00
21_11:00
21_16:00
21_21:00

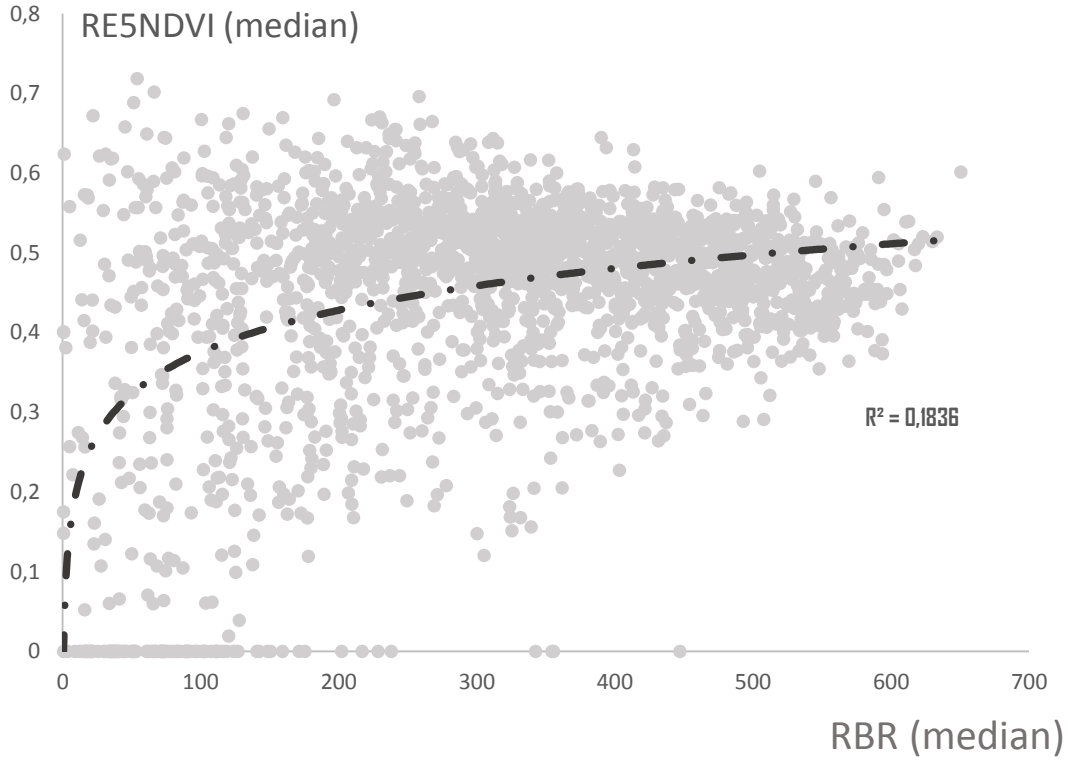
@ CLASS SCALE


700
600
500
400
300
200
100
0
mean RBR
R² = 0,5411
0.01 ha
Hourly fire growth
400.00 ha


800
700
600
500
400
300
200
100
0
RBR (median)
R² = 0,4846
0.01 ha
Hourly fire growth
400.00 ha

@ CLASS SCALE

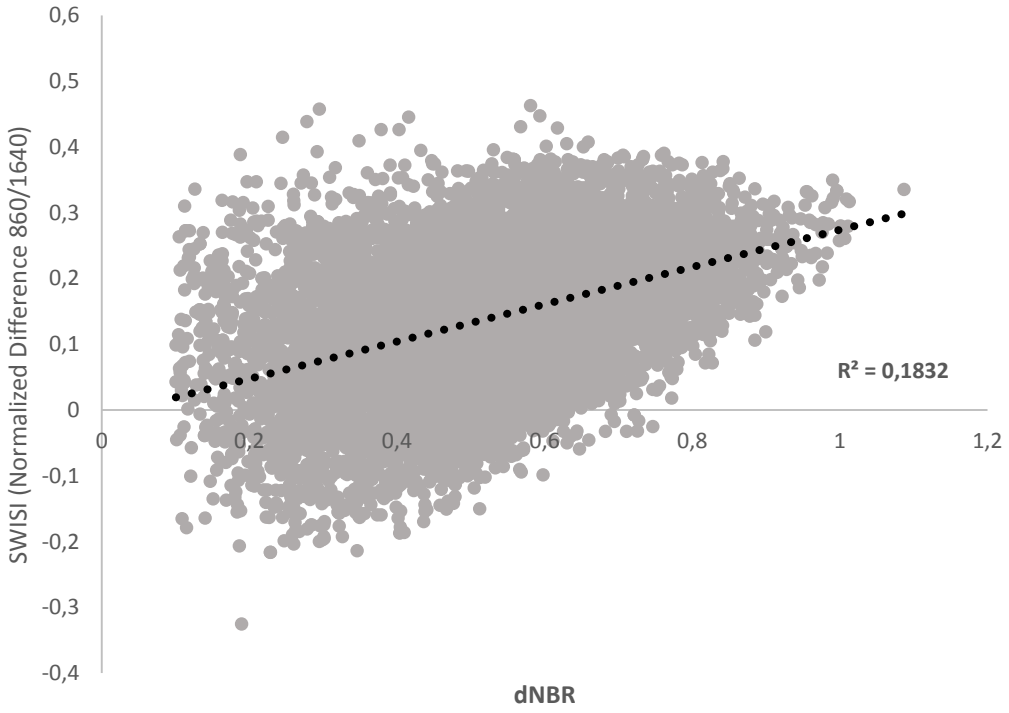




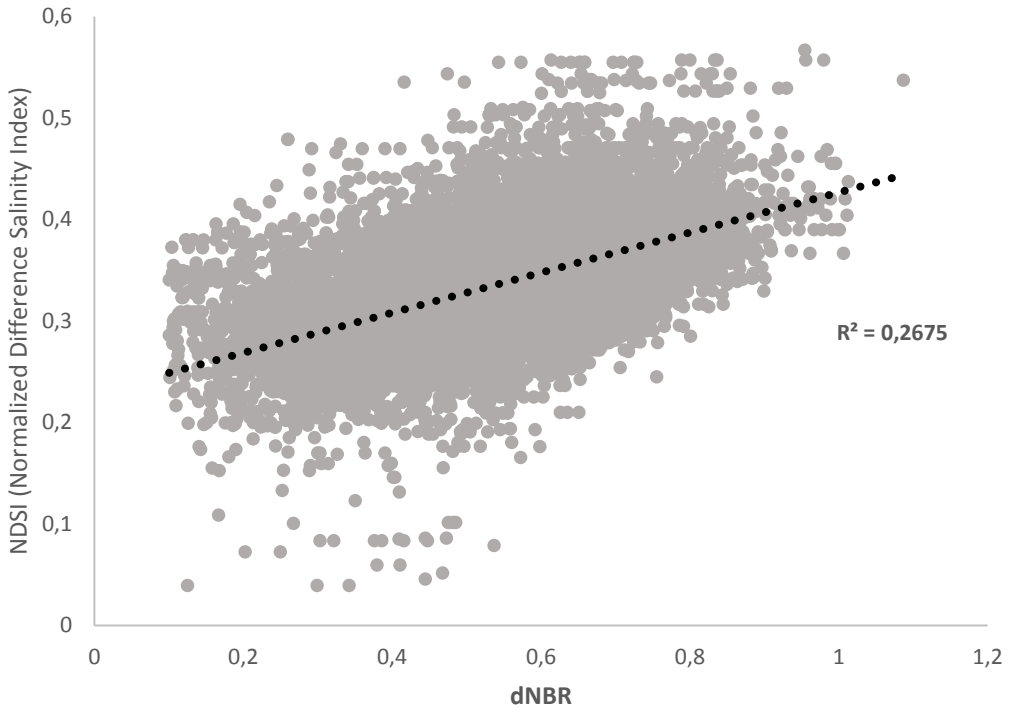
NDI45 is very sensitive to the chlorophyll content present in the canopy and, therefore, is normally a significant predictor of tree canopy attributes and plant vitality (Wang et al., 2016; Zimmermann et al., 2020; Nasiri et al., 2022).

RE5NDVI (Red-Edge Normalized Vegetation Index; Gitelson & Merzlyak, 1996) performs better than NDVI in estimating biomass

@ PIXEL SCALE



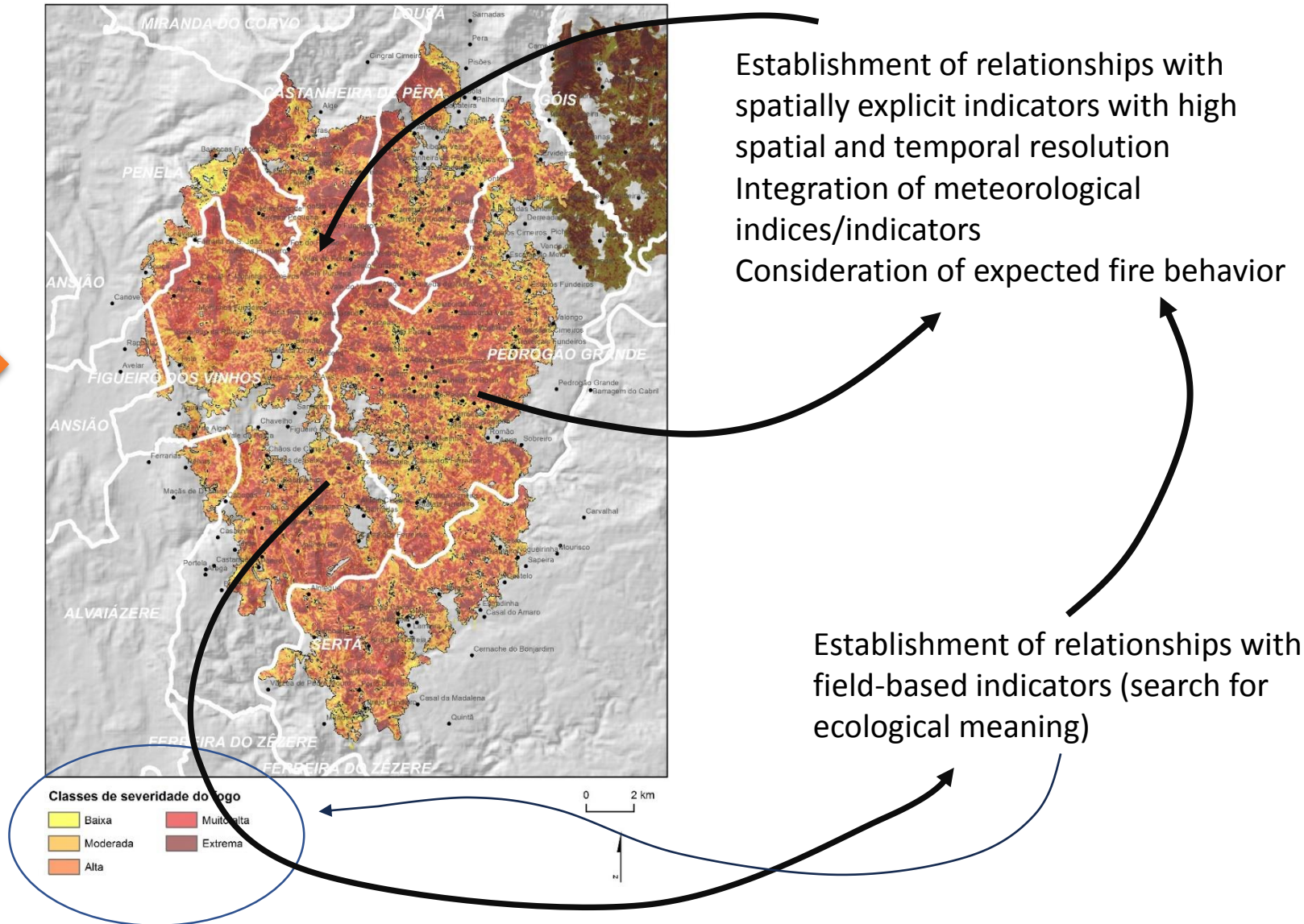
Estimate leaf of canopy water stress, especially in the semiarid environment.



Inversely proportional to water content (used as an indicator of vegetation health)

THE PATHWAY FOR THE ULTIMATE OBJECTIVE

THE PATHWAY TO MODELING FIRE'S POTENTIAL SEVERITY



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