IA 2.2: Scheduling and implementing novel management practices

Methodology to evaluate cost-effective management alternatives at the stand-level for increasing fire resistance (section 1)

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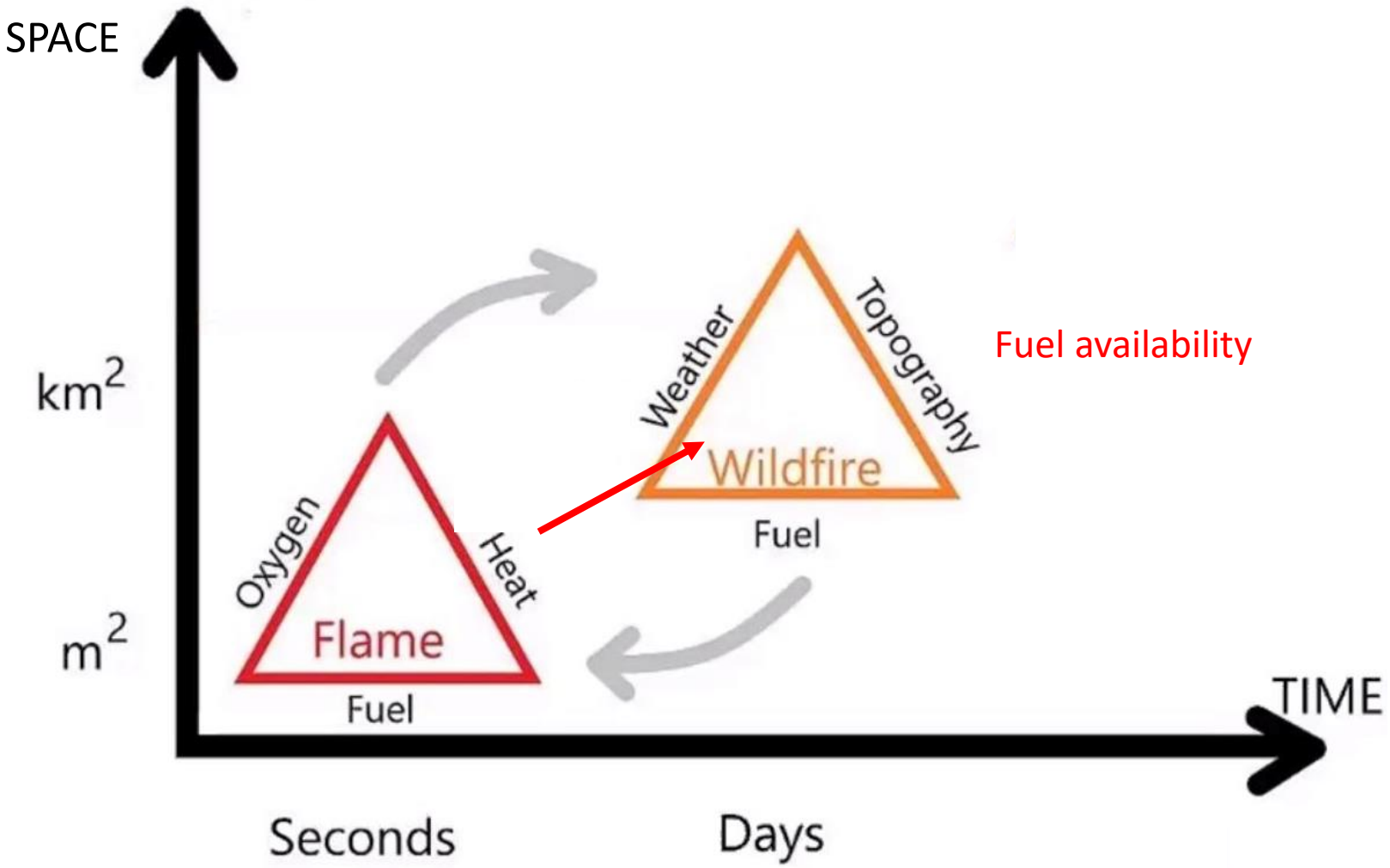
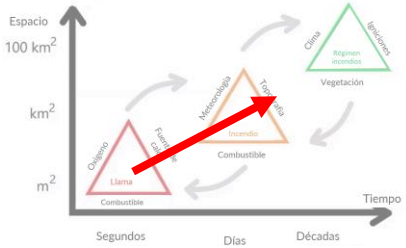
Context



Adapted from Moritz *et al.*

Context



- Fire spread is possible only above a given fuel availability threshold.

- **Fuel availability (how ready a fuel is for burning)**:
  - Fuel load (kg/m2)
  - Fuel continuity
  - Dead to live fuel ratio

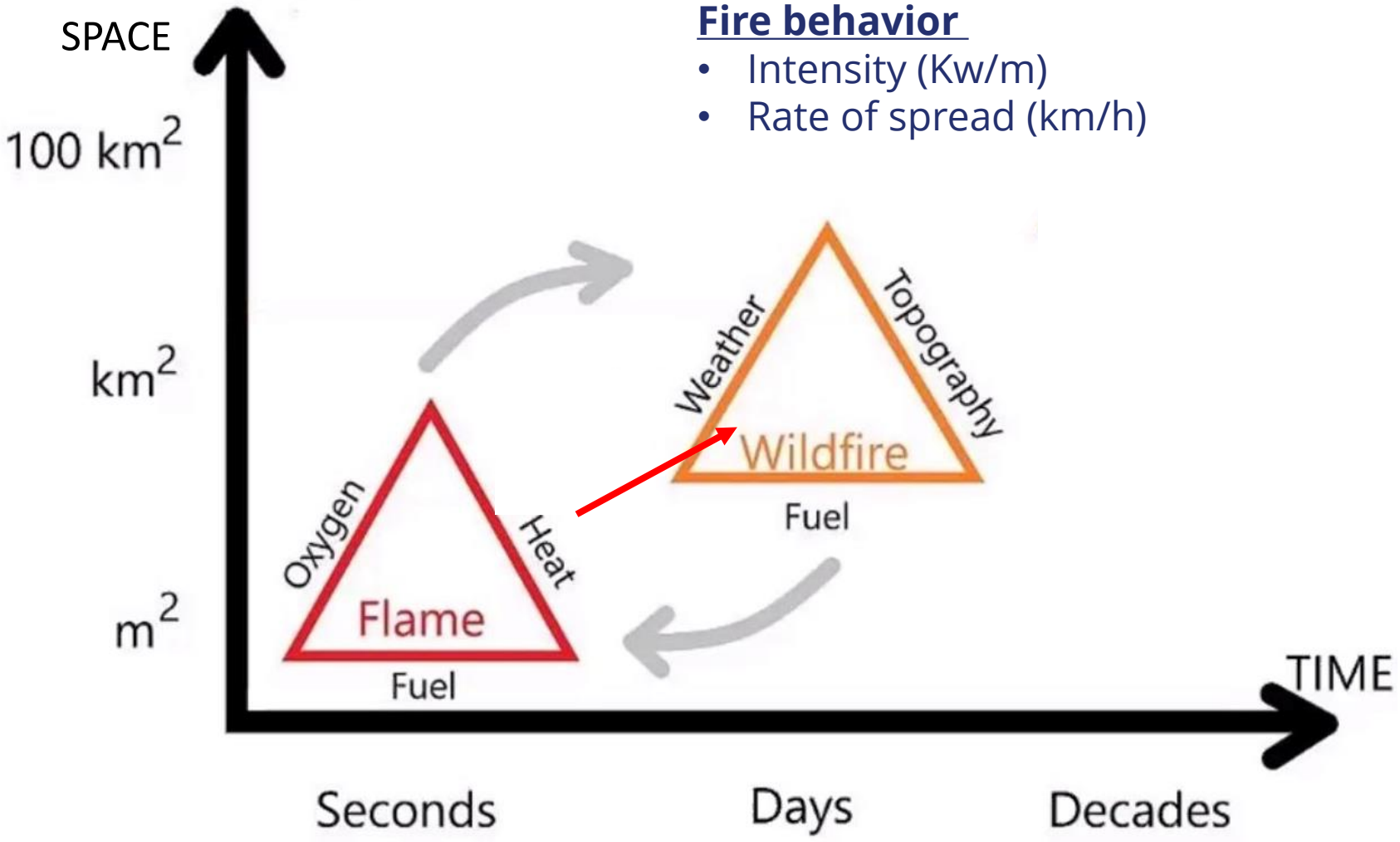
Fine dead fuel (1-h fuel load)

Medium dead fuel (10-h fuel load)

Context

Fire behavior

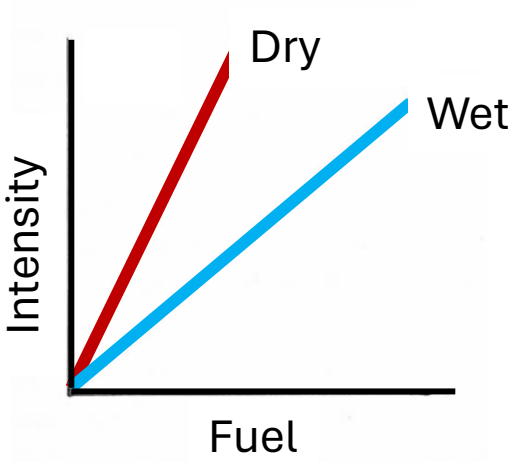
- Intensity (Kw/m)
- Rate of spread (km/h)



Context

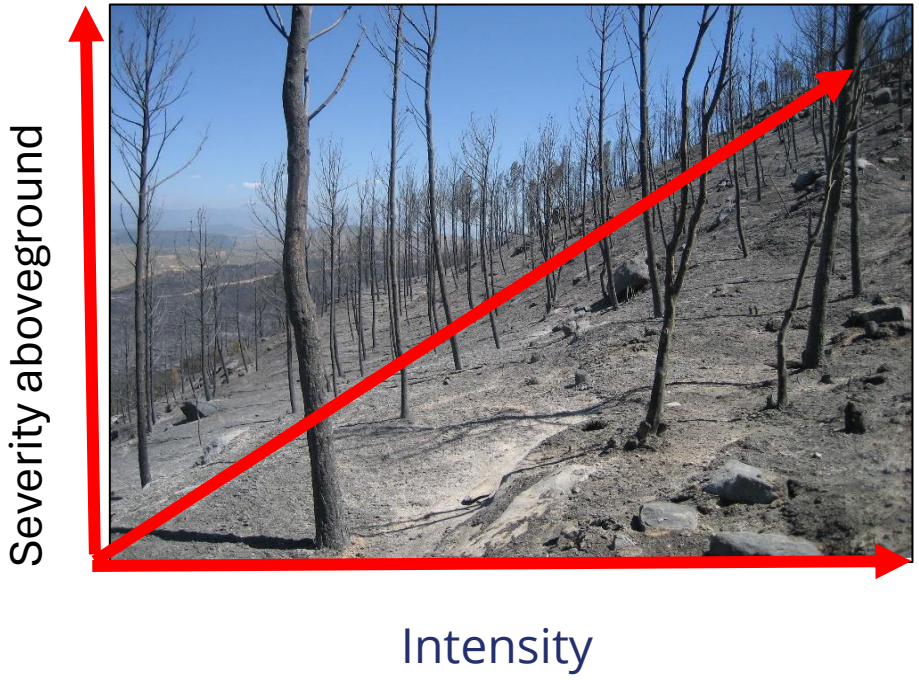
Fire behavior

- **Intensity (Kw/m)**
- Rate of spread (km/h)
- Flame length



Fire severity

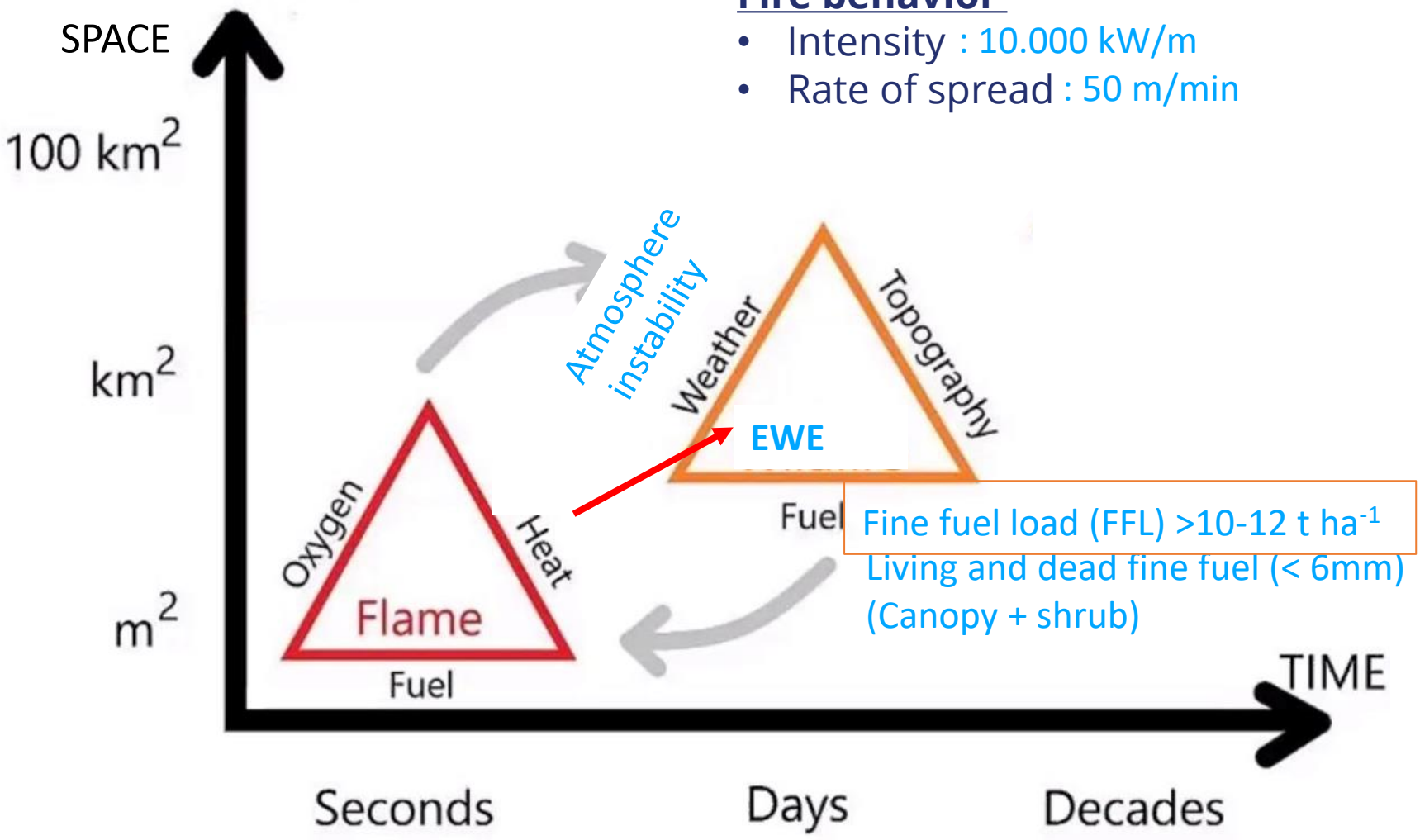
- **Loss of organic mater**
  - Below and aboveground



Context

Fire behavior

- Intensity : 10.000 kW/m
- Rate of spread : 50 m/min

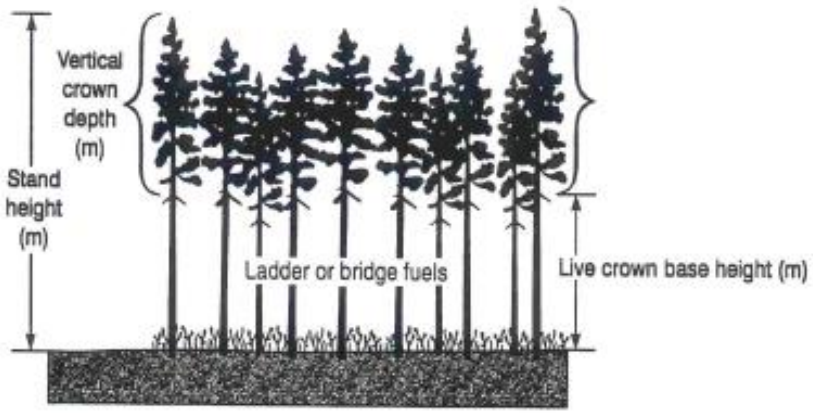


Fine fuel load (FFL) >10-12 t ha^{-1}
Living and dead fine fuel (< 6mm)
(Canopy + shrub)

Context

- **Resistance:** the capacity to continue providing functions and ecosystem services **immediately after the event.**
  - Intensity
  - Forest structure

Thinning intensity?
Height of pruning?



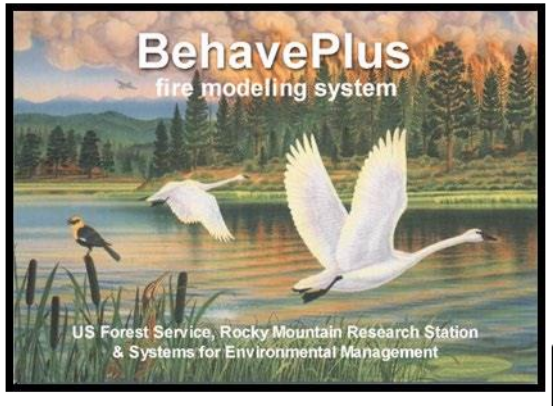
- **Increasing stand resistance**:
  - Reducing surface fuel load
  - Increasing crown base height
  - Decreasing crown density

- Reduce the severity of the fire.
- Help extinction tasks

(Agee and Skinner, 2005)

Context

- Fire behaviour systems
  - To assess crown fire hazard (manager tool)
  - Compare:
    - Crown fire potential of different stands
    - Effectiveness of fuel treatments



Context

Thinning intensity?
Height of pruning?

- Cost-effective?

Pre-treatment

Post-treatment

- Fuel treatments

Objective

Develop a methodology that allows to evaluate cost-effective management alternatives at the stand-level for increasing fire resistance.

Forest management strategy	Treatments	
	Thinning	Slash treatment
Multifunctional management focusing on wildfire prevention		
Conversion to silvopastoral system		 
Prescribed burning		

Objective

Develop a methodology that allows to evaluate cost-effective management alternatives at the stand-level for increasing fire resistance.

- The list of treatments in each management strategy has been proposed for the main forest types in Catalonia and for three stages of development.

Forest type
Pinus halepensis forests
Pinus sylvestris forests
Quercus ilex forests
Pinus nigra forests
Pinus uncinata forests
Quercus humilis forests
Quercus suber forests
Pinus pinea forests
Quercus faginea forests

	Management strategy		
Stand stage	**Multifunctional management focusing on Wildfire prevention**	**Conversion to silvopastoral system**	**Prescribed burning**
Young	x	x (1)	
Mid-age	x	x	x
Adult	x	x	x

Methods

1. Definition of pre- and post-treatment structures using stand parameters.
2. Fire behavior modelling system: inputs.
3. Integrating stand parameters into fire simulators.

- Using management guidelines of Catalonia.

Pre- treatment

- Height
- Forest cover
- Tree density
- DBH
- Basal area
- Shrub cover
- Shrub height

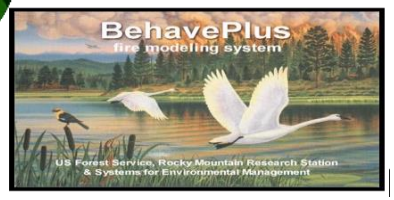
Post- treatment

- Height
- Forest cover
- Tree density
- DBH
- Basal area
- Shrub cover
- Shrub height

Development stages	Treatment	H (m)	CC (%)	N (tree ha^{-1})	DBH (cm)	BA (m^2 ha^{-1})	SC (%)	SH (m)
Regenerated-Young forest								
Pre-treatment		4-6	≈100	6000	6			
Post-treatment	Pre-commercial thinning	6	≈70	1800	8-10	20	<30	<1.3
Mid-age forest								
Pre-treatment		6-12	>70	1600	15-17	30-40	>50	>1.3
Post-treatment	Clearing + low thinning	12	≈70	850	20	20-30[1]	<30	<1.3
Adult forest								
Pre-treatment		>12	>70	750	28-30	>30	>50	>1.3
Post-treatment	Clearing + mixed thinning	>14	≈70	500	32	>20[1]	<30	<1.3

[1]The pre-treatment basal area has been reduced in 30%.

Methods



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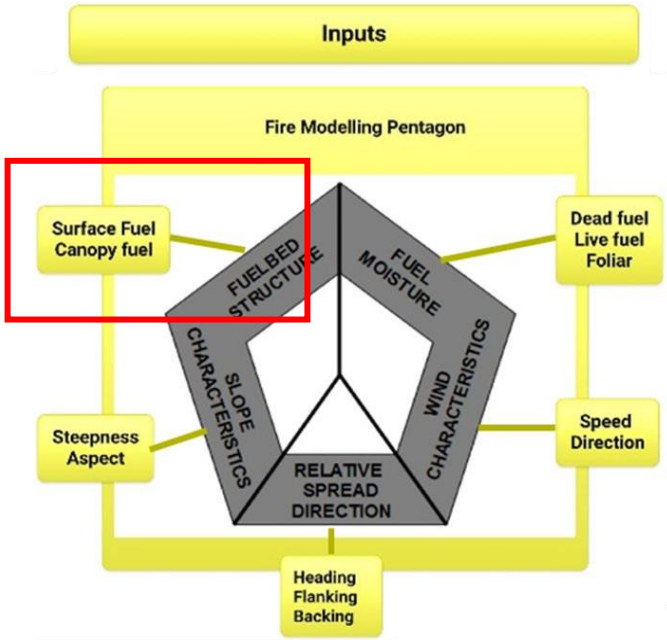

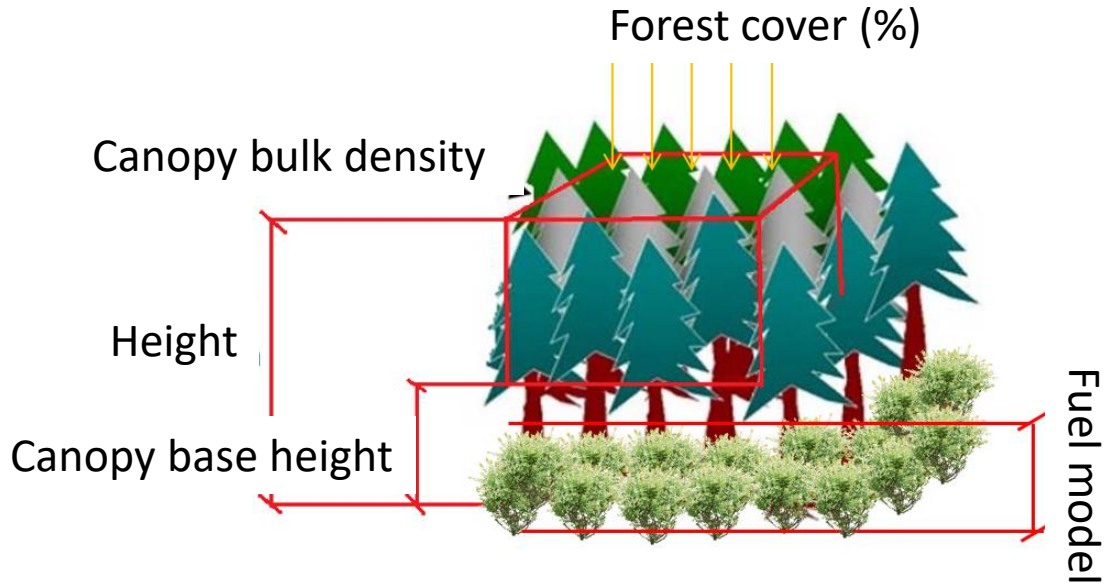

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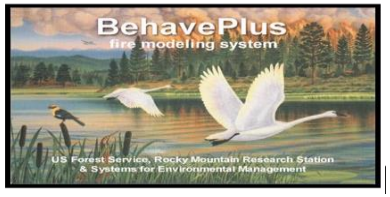
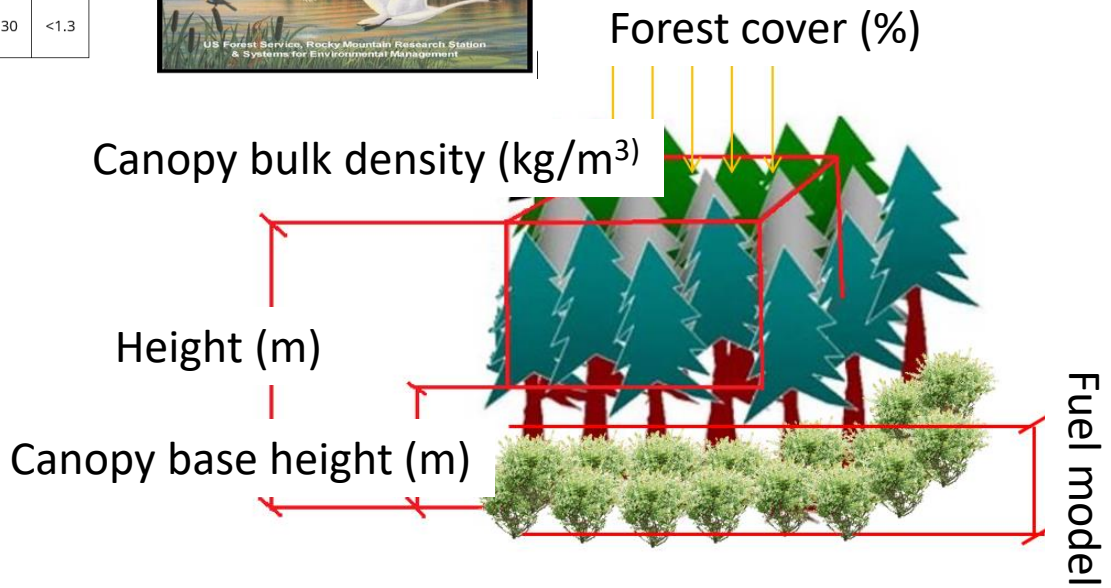
- Height (m)
- Forest cover (%)
- Tree density (trees/ha)
- DBH (cm)
- Basal area (m^2/ha)
- Shrub cover (%)
- Shrub height (cm)





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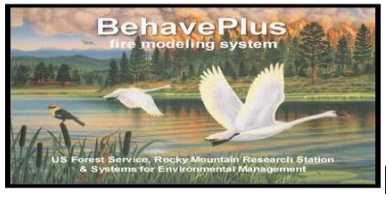
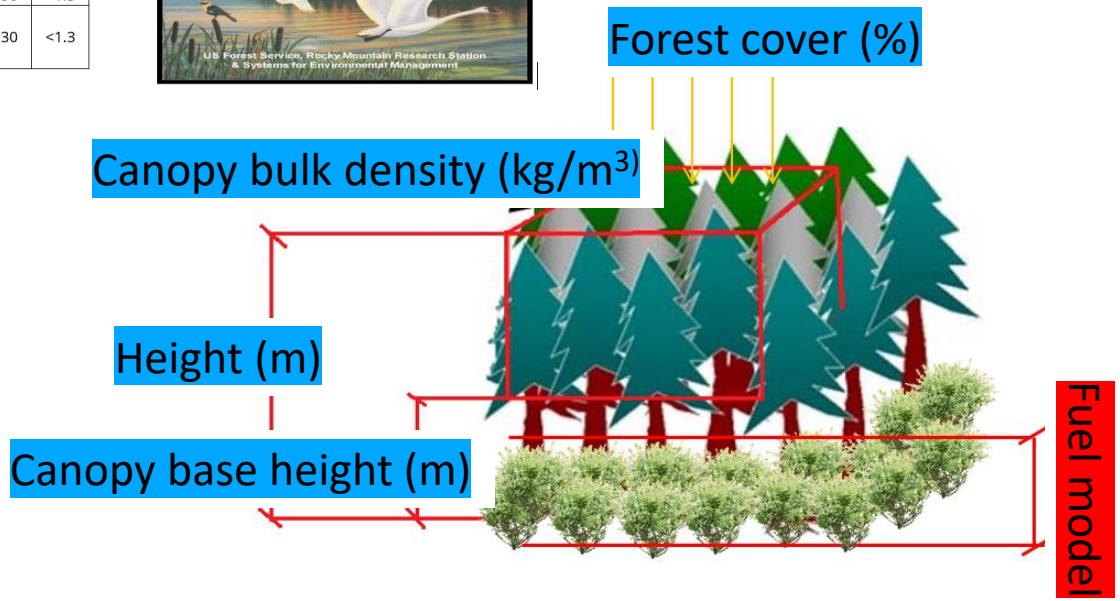


- Height (m)
- Forest cover (%)
- Tree density (trees/ha)
- DBH (cm)
- Basal area (m^2/ha)
- Shrub cover (%)
- Shrub height (cm)



Methods

- Fuel models (FM) are characterized by a set of parameters.

Scott and Burgan (2005)

Table 7—Fuel model parameters.

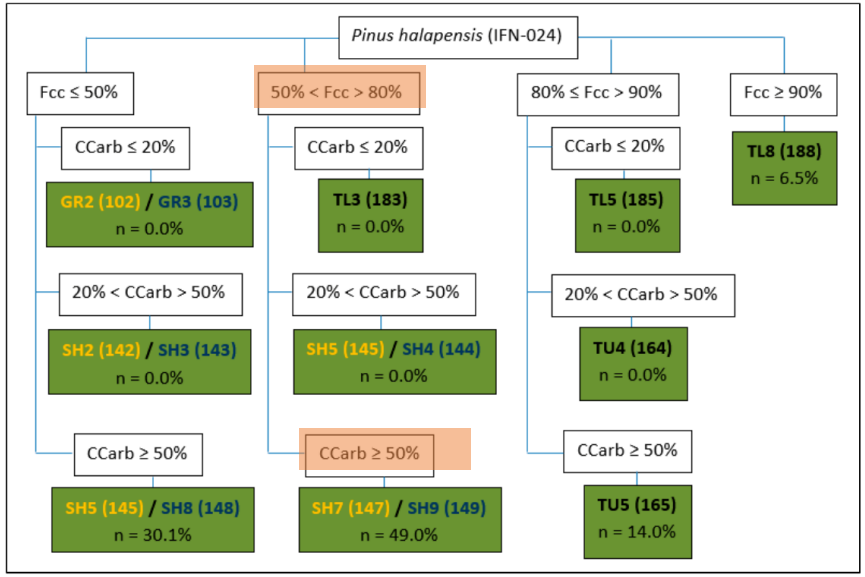
Fuel model code	Fuel load (t/ac) 1-hr	10-hr	100-hr	Live herb	Live woody	Fuel model type[a]	SAV ratio (1/ft)[b] Dead 1-hr	Live herb	Live woody	Fuel bed depth (ft)	Dead fuel extinction moisture (percent)	Heat content BTU/lb[c]
GR1	0.10	0.00	0.00	0.30	0.00	dynamic	2200	2000	9999	0.4	15	8000
GR2	0.10	0.00	0.00	1.00	0.00	dynamic	2000	1800	9999	1.0	15	8000
GR3	0.10	0.40	0.00	1.50	0.00	dynamic	1500	1300	9999	2.0	30	8000
GR4	0.25	0.00	0.00	1.90	0.00	dynamic	2000	1800	9999	2.0	15	8000
GR5	0.40	0.00	0.00	2.50	0.00	dynamic	1800	1600	9999	1.5	40	8000
GR6	0.10	0.00	0.00	3.40	0.00	dynamic	2200	2000	9999	1.5	40	9000
GR7	1.00	0.00	0.00	5.40	0.00	dynamic	2000	1800	9999	3.0	15	8000
GR8	0.50	1.00	0.00	7.30	0.00	dynamic	1500	1300	9999	4.0	30	8000
GR9	1.00	1.00	0.00	9.00	0.00	dynamic	1800	1600	9999	5.0	40	8000
GS1	0.20	0.00	0.00	0.50	0.65	dynamic	2000	1800	1800	0.9	15	8000
GS2	0.50	0.50	0.00	0.60	1.00	dynamic	2000	1800	1800	1.5	15	8000
GS3	0.30	0.25	0.00	1.45	1.25	dynamic	1800	1600	1600	1.8	40	8000
GS4	1.90	0.30	0.10	3.40	7.10	dynamic	1800	1600	1600	2.1	40	8000
SH1	0.25	0.25	0.00	0.15	1.30	dynamic	2000	1800	1600	1.0	15	8000
SH2	1.35	2.40	0.75	0.00	3.85	N/A	2000	9999	1600	1.0	15	8000
SH3	0.45	3.00	0.00	0.00	6.20	N/A	1600	9999	1400	2.4	40	8000
SH4	0.85	1.15	0.20	0.00	2.55	N/A	2000	1800	1600	3.0	30	8000
SH5	3.60	2.10	0.00	0.00	2.90	N/A	750	9999	1600	6.0	15	8000
SH6	2.90	1.45	0.00	0.00	1.40	N/A	750	9999	1600	2.0	30	8000
SH7	3.50	5.30	2.20	0.00	3.40	N/A	750	9999	1600	6.0	15	8000
SH8	2.05	3.40	0.85	0.00	4.35	N/A	750	9999	1600	3.0	40	8000
SH9	4.50	2.45	0.00	1.55	7.00	dynamic	750	1800	1500	4.4	40	8000
TU1	0.20	0.90	1.50	0.20	0.90	dynamic	2000	1800	1600	0.6	20	8000
TU2	0.95	1.80	1.25	0.00	0.20	N/A	2000	9999	1600	1.0	30	8000
TU3	1.10	0.15	0.25	0.65	1.10	dynamic	1800	1600	1400	1.3	30	8000
TU4	4.50	0.00	0.00	0.00	2.00	N/A	2300	9999	2000	0.5	12	8000
TU5	4.00	4.00	3.00	0.00	3.00	N/A	1500	9999	750	1.0	25	8000
TL1	1.00	2.20	3.60	0.00	0.00	N/A	2000	9999	9999	0.2	30	8000
TL2	1.40	2.30	2.20	0.00	0.00	N/A	2000	9999	9999	0.2	25	8000
TL3	0.50	2.20	2.80	0.00	0.00	N/A	2000	9999	9999	0.3	20	8000
TL4	0.50	1.50	4.20	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL5	1.15	2.50	4.40	0.00	0.00	N/A	2000	9999	1600	0.6	25	8000
TL6	2.40	1.20	1.20	0.00	0.00	N/A	2000	9999	9999	0.3	25	8000
TL7	0.30	1.40	8.10	0.00	0.00	N/A	2000	9999	9999	0.4	25	8000
TL8	5.80	1.40	1.10	0.00	0.00	N/A	1800	9999	9999	0.3	35	8000
TL9	6.65	3.30	4.15	0.00	0.00	N/A	1800	9999	1600	0.6	35	8000
SB1	1.50	3.00	11.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB2	4.50	4.25	4.00	0.00	0.00	N/A	2000	9999	9999	1.0	25	8000
SB3	5.50	2.75	3.00	0.00	0.00	N/A	2000	9999	9999	1.2	25	8000
SB4	5.25	3.50	5.25	0.00	0.00	N/A	2000	9999	9999	2.7	25	8000

[a] Fuel model type does not apply to fuel models without live herbaceous load.
[b] The value 9999 was assigned in cases where there is no load in a particular fuel class or category
[c] The same heat content value was applied to both live and dead fuel categories.

- Adapt or calibrate the NFFL classification to own conditions.

Methods

- Catalonia
  - 40 fuel model of Sc0tt and Burgan (2005) tied to Catalonian forest types and structures (Krsnick et al. 2022)
- Forest and shrub cover (%)



Scott and Burgan (2005)

Fuel Model sh7

Fuel Model Number	147	
Fuel Model Name	sh7	
Fuel Model Type	Static	
Description	Very high load, dry climate shrub (S)	
1-h Fuel Load	3.5 tons/ac	7.8 tonnes/ha
10-h Fuel Load	5.3 tons/ac	12 tonnes/ha
100-h Fuel Load	2.2 tons/ac	4.9 tonnes/ha
Live Herbaceous Fuel Load	0 tons/ac	0 tonnes/ha
Live Woody Fuel Load	3.4 tons/ac	7.6 tonnes/ha
1-h Surface Area/Vol Ratio	750 ft2/ft3	24.6063 cm2/cm3
Live Herbaceous Surface Area/Vol Ratio	1800 ft2/ft3	59.0551 cm2/cm3
Live Woody Surface Area/Vol Ratio	1600 ft2/ft3	52.4934 cm2/cm3
Fuel Bed Depth	6 feet	182.88 cm
Dead Fuel Moisture of Extinction	15 percent	15 percent
Dead Fuel Heat Content	8000 Btu/lb	18622.3 KJ/Kg
Live Fuel Heat Content	8000 Btu/lb	18622.3 KJ/Kg

[c] The value 9999 was assigned in cases where there is no load in a particular fuel class or category
[c] The same heat content value was applied to both live and dead fuel categories.

medfuels

R package to estimate individual fuel biomass and stand-level fuel loading for Catalonia, Spain

Methods

1. Definition of pre- and post-treatment structures using stand parameters.

Development stages	Treatment	H (m)	CC (%)	N (tree ha^{-1})	DBH (cm)	BA (m^2 ha^{-1})	SC (%)	SH (m)
Regenerated-Young forest								
Pre-treatment		4-6	≈100	6000	6			
Post-treatment	Pre-commercial thinning	6	≈70	1800	8-10	20	<30	<1.3
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Pre-treatment		6-12	>70	1600	15-17	30-40	>50	>1.3
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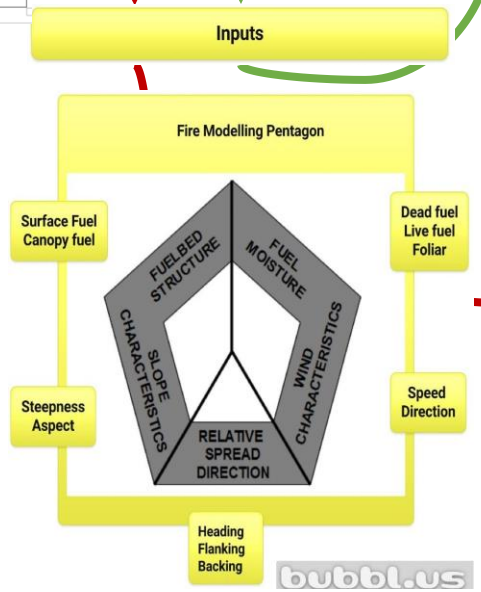
[1]The pre-treatment basal area has been reduced in 30%

2. Integrating stand parameters into fire simulators.



3. Fire behavior before and after treatments.

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Pre-treatment

20-ft Wind mi/h	Fireline Intensity Btu/ft/s	Flame Length ft	Trans Ratio	Transition to Crown?	Active Ratio	Active Crown?	Fire Type
0	31	2.2	0.73	No	0.07	No	Surface
5	61	3.0	1.44	Yes	0.26	No	Torching
10	112	3.9	2.65	Yes	0.59	No	Torching
15	176	4.9	4.16	Yes	0.99	No	Torching
20	250	5.7	5.91	Yes	1.46	Yes	Crowning
25	333	6.5	7.86	Yes	1.98	Yes	Crowning
30	422	7.3	9.98	Yes	2.54	Yes	Crowning

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Post-treatment

20-ft Wind mi/h	Fireline Intensity Btu/ft/s	Flame Length ft	Trans Ratio	Transition to Crown?	Active Ratio	Active Crown?	Fire Type
0	31	2.2	0.73	No	0.07	No	Surface
5	61	3.0	1.44	Yes	0.26	No	Torching
10	112	3.9	2.65	Yes	0.59	No	Torching
15	176	4.9	4.16	Yes	0.99	No	Torching
20	250	5.7	5.91	Yes	1.46	Yes	Crowning
25	333	6.5	7.86	Yes	1.98	Yes	Crowning
30	422	7.3	9.98	Yes	2.54	Yes	Crowning

Example of result

We can evaluate the effect of the treatment on both the structure, the fuel loads and the behavior of the potential fire.

Pinus halepensis

Fuel hazard

			Regenerated crop		Young Forest		Adult forest		Regenerated crop		Young Forest		Adult forest		Young Forest		Adult forest	
	Fuel Bed	m	0.5	-41%	0.5	-52%	0.5	-63%	0.25	-71%	0.25	-76%	0.25	-81%	0.1	-90%	0.1	-93%
	Canopy cover	%	70.00	-30%	70.00	-13%	70.00	-13%	70.00	-30%	70.00	-13%	70.00	-13%	60.00	-25%	60.00	-25%
	Canopy Base Height	m	2.37	32%	5.84	42%	7.00	21%	2.37	32%	5.84	42%	7.00	21%	6.40	56%	7.60	31%
	Canopy Bulk Density	kg/m3	0.12	-67%	0.14	-36%	0.20	-29%	0.12	-67%	0.14	-36%	0.20	-29%	0.14	-36%	0.18	-36%
	CARB (SHC)	%	25.00	-77%	25.00	-77%	25.00	-78%	20.00	-82%	20.00	-82%	20.00	-82%	10.00	-91%	10.00	-91%
	Vertical continuity (VC)	m	1.87	99%	5.34	75%	6.50	46%	2.12	126%	5.59	83%	6.75	51%	6.30	106%	7.50	68%
	Crown fire type	---	Torching	C>T	Surface	C>S	CondCrown	C>CC	Surface	C>S	Surface	C>S	CondCrown	C>CC	Surface	C>S	CondCrown	C>CC
	Rate of spread	m/min	18.4	-16%	2.3	-89%	2	-89%	0.5	-98%	0.5	-98%	0.5	-97%	0.2	-99%	0.2	-99%
TFA meteo scenario	Fire intensity	kW/m	8666	-71%	808	-97%	661	-97%	25	-100%	25	-100%	20	-100%	9	-100%	7	-100%
	Flame lenght	m	11.2	-56%	1.7	-93%	1.5	-93%	0.3	-99%	0.3	-99%	0.3	-99%	0.2	-99%	0.2	-99%
	Scorch height	m	11.2	-77%	10.4	-81%	9.1	-83%	0.6	-99%	0.6	-99%	0.5	-99%	0.2	-100%	0.1	-100%
	Crowning index	km/h	31.8	133%	29.3	41%	25.2	29%	31.8	133%	29.3	41%	25.2	29%	29.3	41%	27.3	40%

Fire behavior

At the same time, since the costs of each management strategy will be budgeted, it is also possible to evaluate which management alternative is the best in terms of cost-efficiency.

Thank you!

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