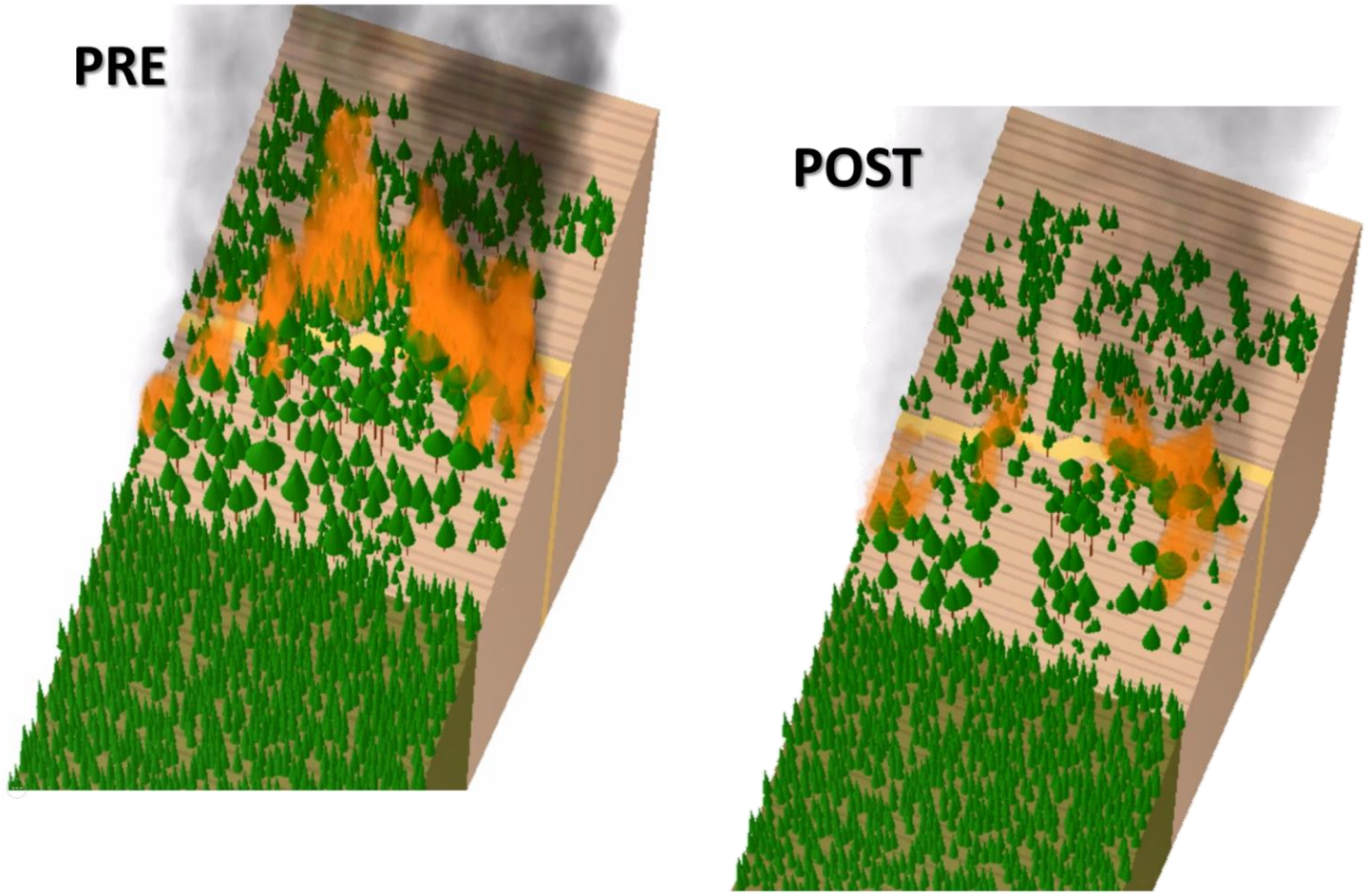
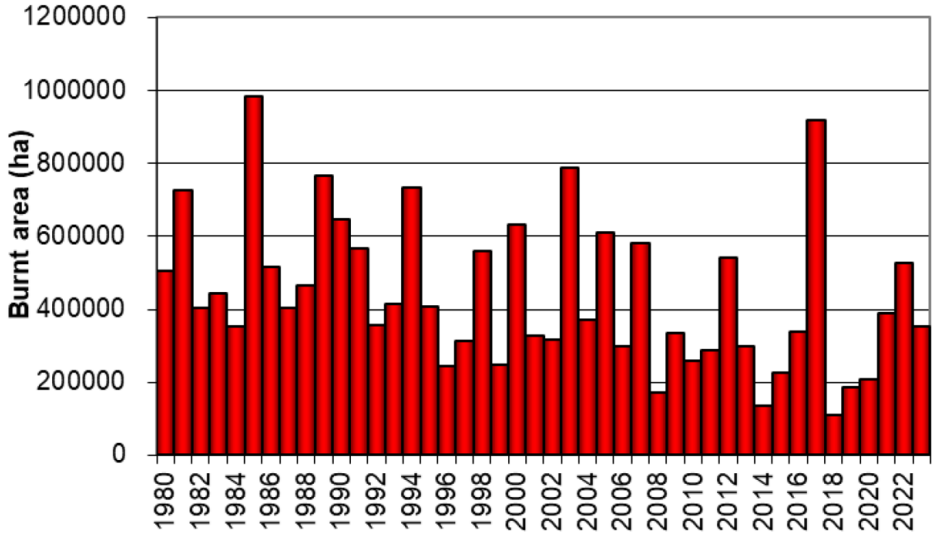
CloseR to nature pyro-sylviculture in Mediterranean forests: from the landscape to the stand scale



Roberta Berretti
Renzo Motta
Davide Ascoli

University of Torino

Wildfire impacts in Europe



So 2025. European Communities

Wildfire impacts in Europe

Southern Europe from 1980 to 2024

Burnt area: ~ 20 millions of hectares (es. ~ 2 x forest area in Italy)

Deaths due to wildfires (fire fighters-civils): ~34 persons/year

Economical losses: about **3 billions Euro/year**

Wildfire Impacts in 2017

Burnt area: 1 millions of hectares

Deaths (fire fighters-civils): 127

Losses: > 9.8 billions Euro

Source: San-Miguel Ayanz, EFFIS, JRC

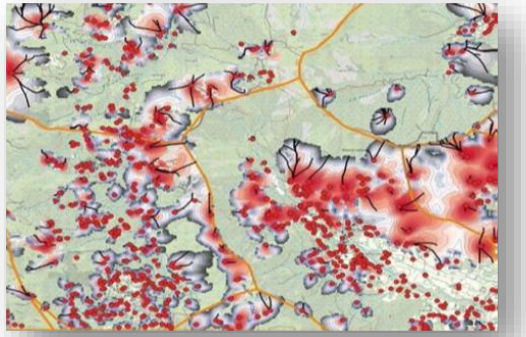
Pedrograo Grande
June 2017

Landscape: strategic wildfire risk mitigation

Wildfire risk mitigation: two scales

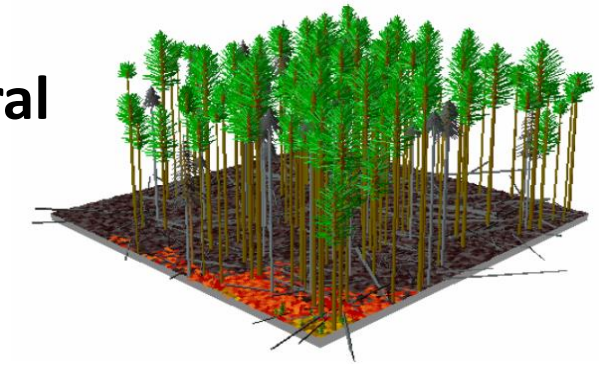
1) Landscape scale

Strategic wildfire risk mitigation at the landscape identifies fire risk and guide the location and dimensioning of preventive infrastructures (e.g., supporting fire fighting – increasing the resistance of forest ecosystem services)



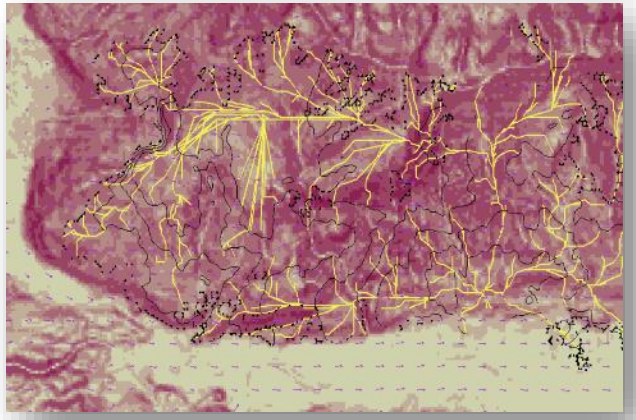
2) Stand scale

Creating **preventive infrastructures** in forests (e.g., shaded fuel breaks, self-resistance forests), through **pyro-silvicultural** treatments (e.g., variable retention and prescribed burning to mitigate crown fire) under **closer to nature** principles



Closer-to-nature?

Landscape: strategic wildfire risk mitigation



Expert assessment

Analysis tools

Burn probability

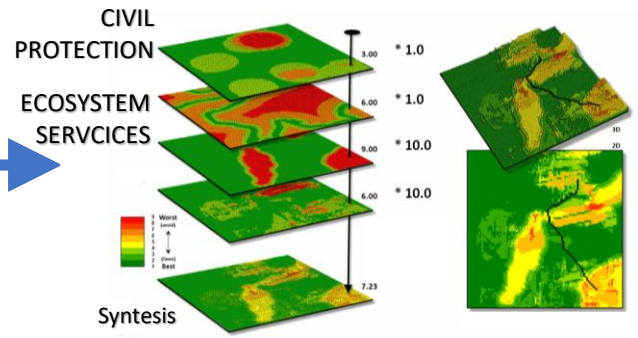
Preferential trajectories

Potential intensity

Fire hazard

Wildfire risk

Vulnerability to fire



Multicriteria analysis

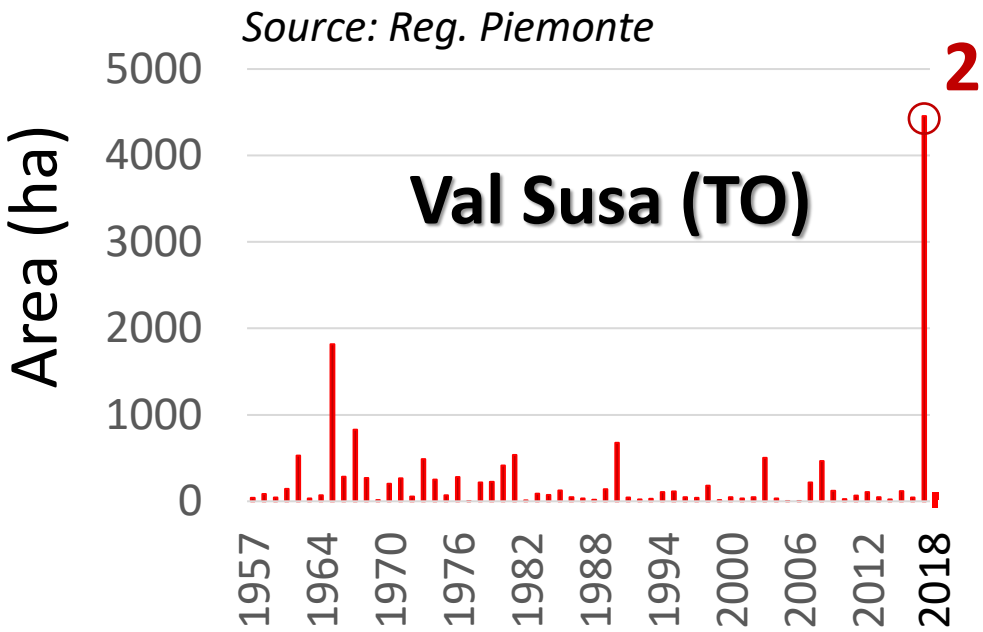
Mitigation scenarios

Spatial ditribution

Preventive infrastructures

Closer-to-nature?

Landscape: strategic wildfire risk mitigation



Example

Extreme fires in the Alps

In **autumn 2017** in Val Susa (Piedmont), a fire covered **3974** ha (65% forest).

On the same days there were 8 other large fires (total 10,000 ha)

Landscape: strategic wildfire risk mitigation

Extreme wildfire behaviour

520 has crown fire

Flame length up to 50 m

Intensity 30,000 - 50,000 kW/m

GHG emissions (ton.)

CO_2	CO	NOx	CH_4	PM_{10}
51728	9402	25	433	851

Source: Bacciu, CMCC; Scarpa, UNISS

Landscape: strategic wildfire risk mitigation

Effects mid-high severity

47% of the burnt area

1186 ha of forests

53% direct protection

9% productive

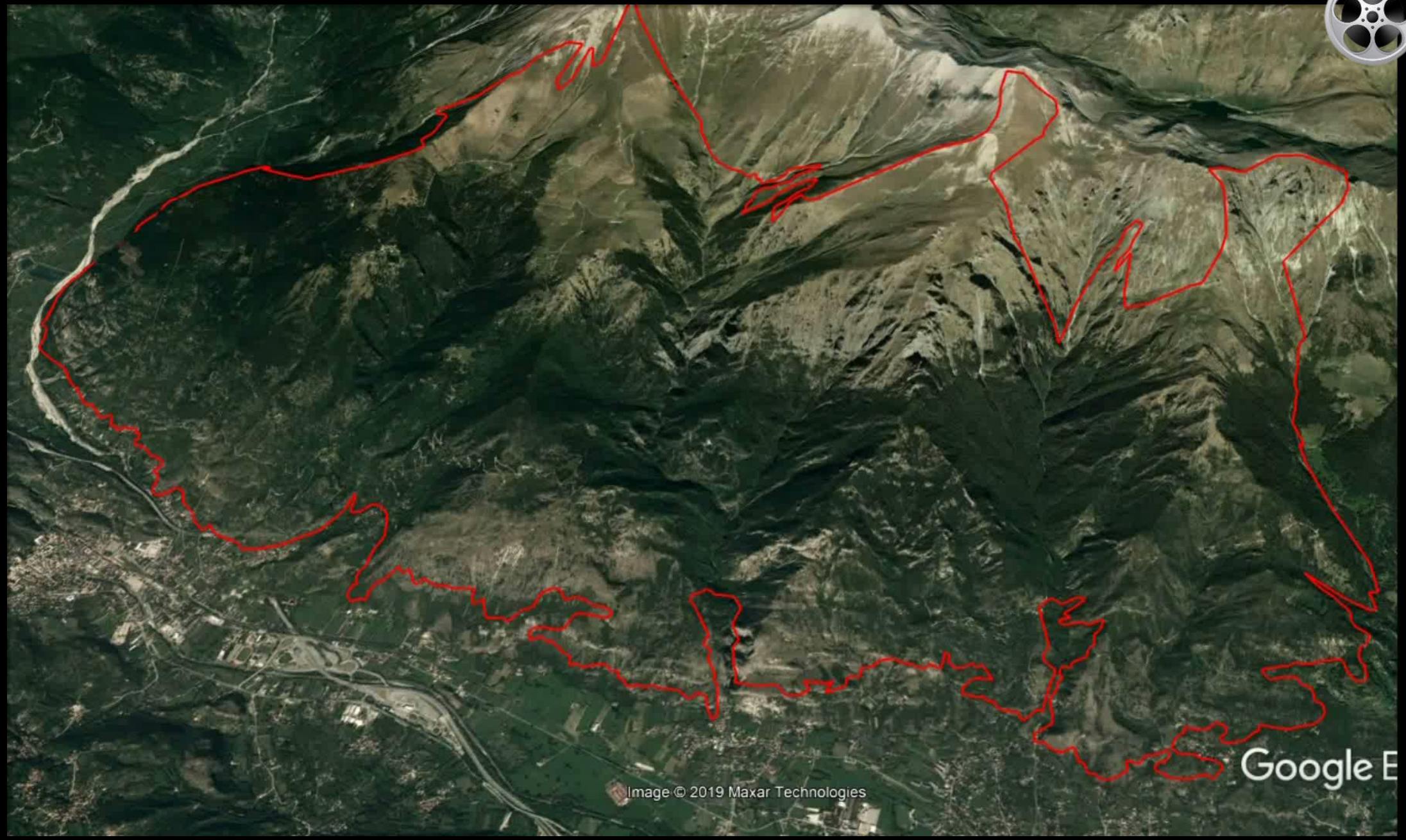
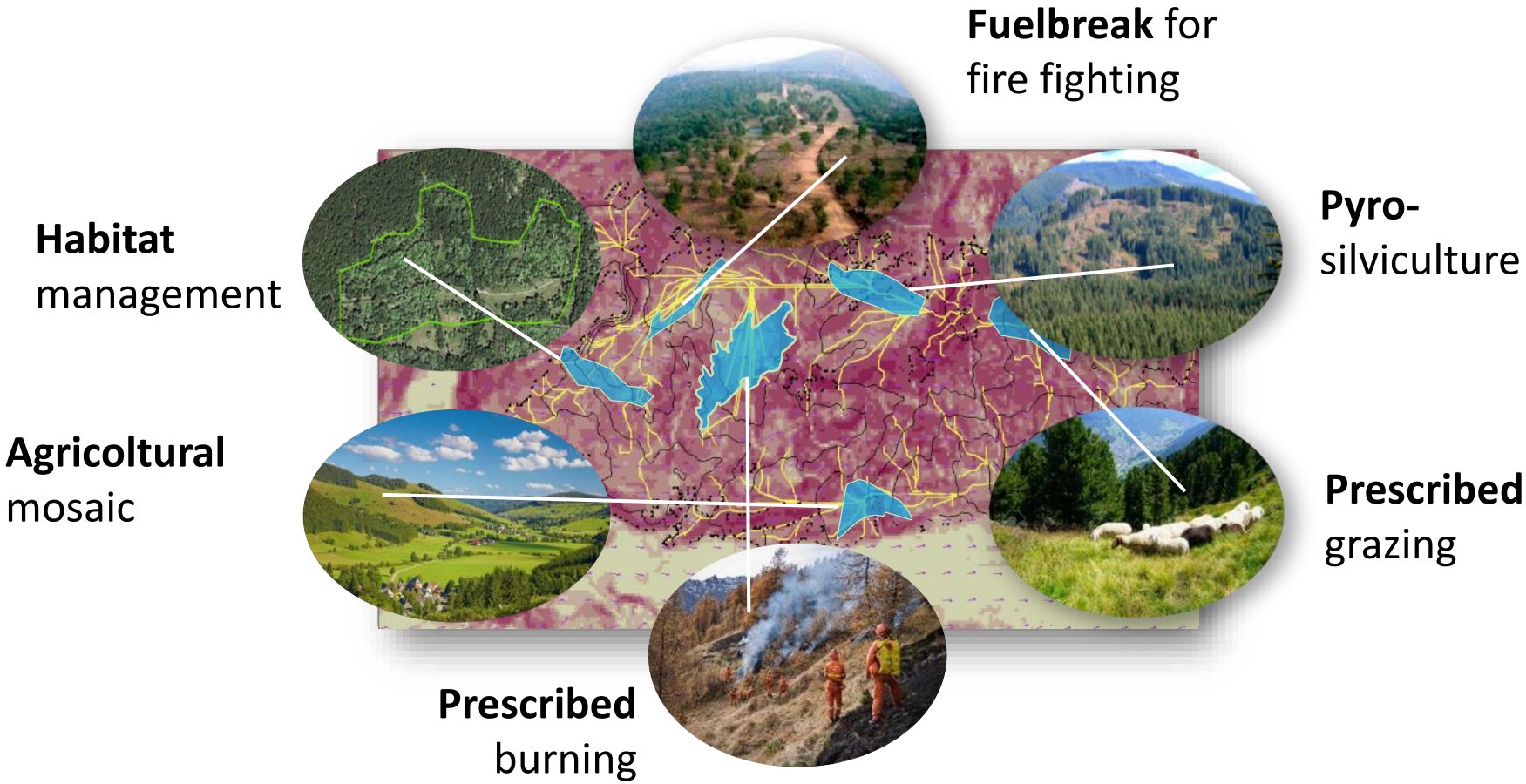


Image © 2019 Maxar Technologies
Google E

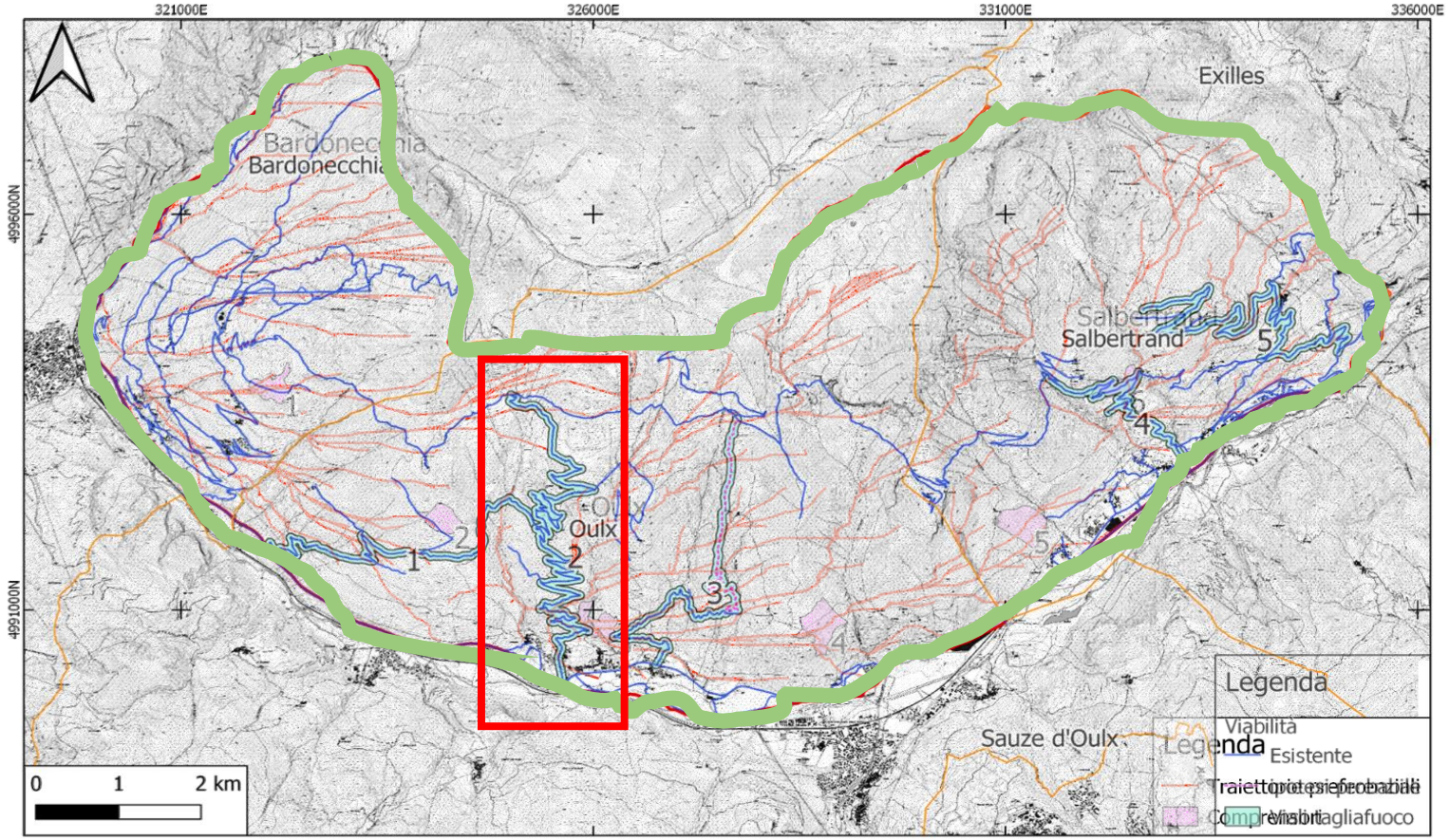
Landscape: strategic wildfire risk mitigation

Wildfire **risk mitigation plans** identify the **spatial distribution** and sizing of **preventive infrastructures** based on the risk analysis and the **expected behavior of large fires**



Landscape: strategic wildfire risk mitigation

Wildfire **risk mitigation plans** identify the **spatial distribution** and sizing of **preventive infrastructures** based on the risk analysis and the **expected behavior of large fires**



Forest district

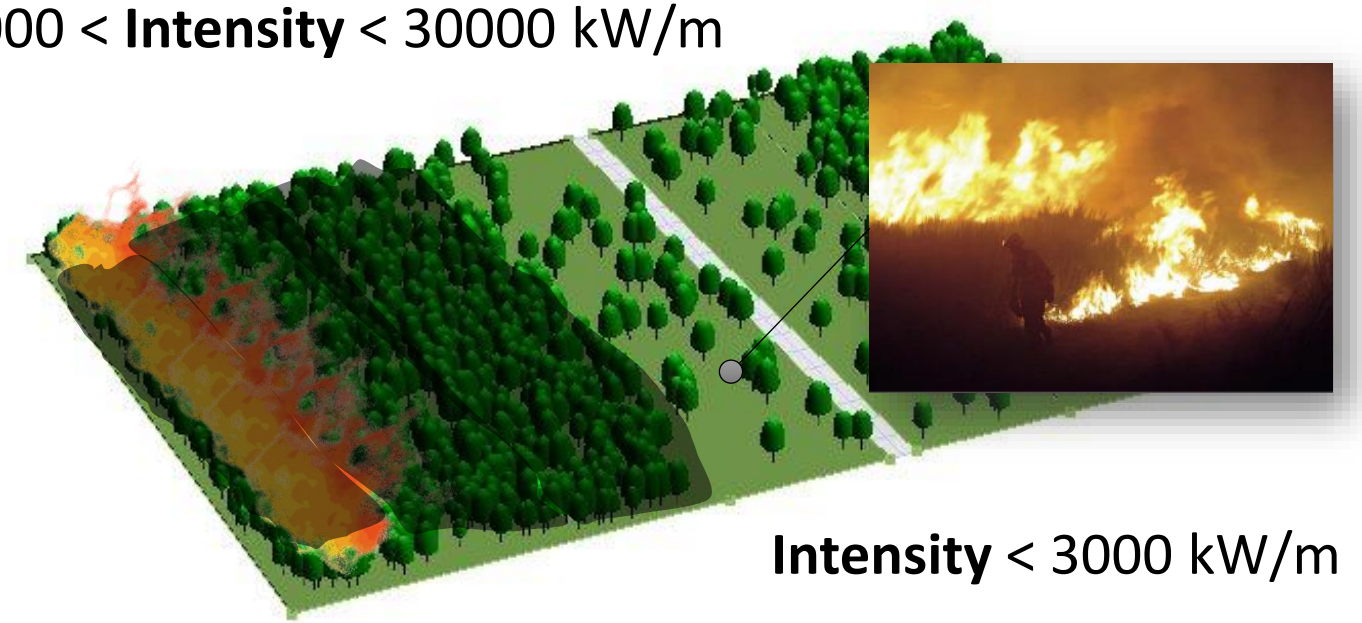
Preferential
fire trajectories

Self-resistant
forests

Shaded
fuel-breaks

Stand scale: infrastructures to increase fire fighting capacity and safety

3000 < **Intensity** < 30000 kW/m



Intensity < 3000 kW/m

E.g. Shaded fuelbreaks

To make **active firefighting** more **effective** and **safer**, the fuel-break must **mitigate** the intensity and make it **compatible** with direct or indirect attack

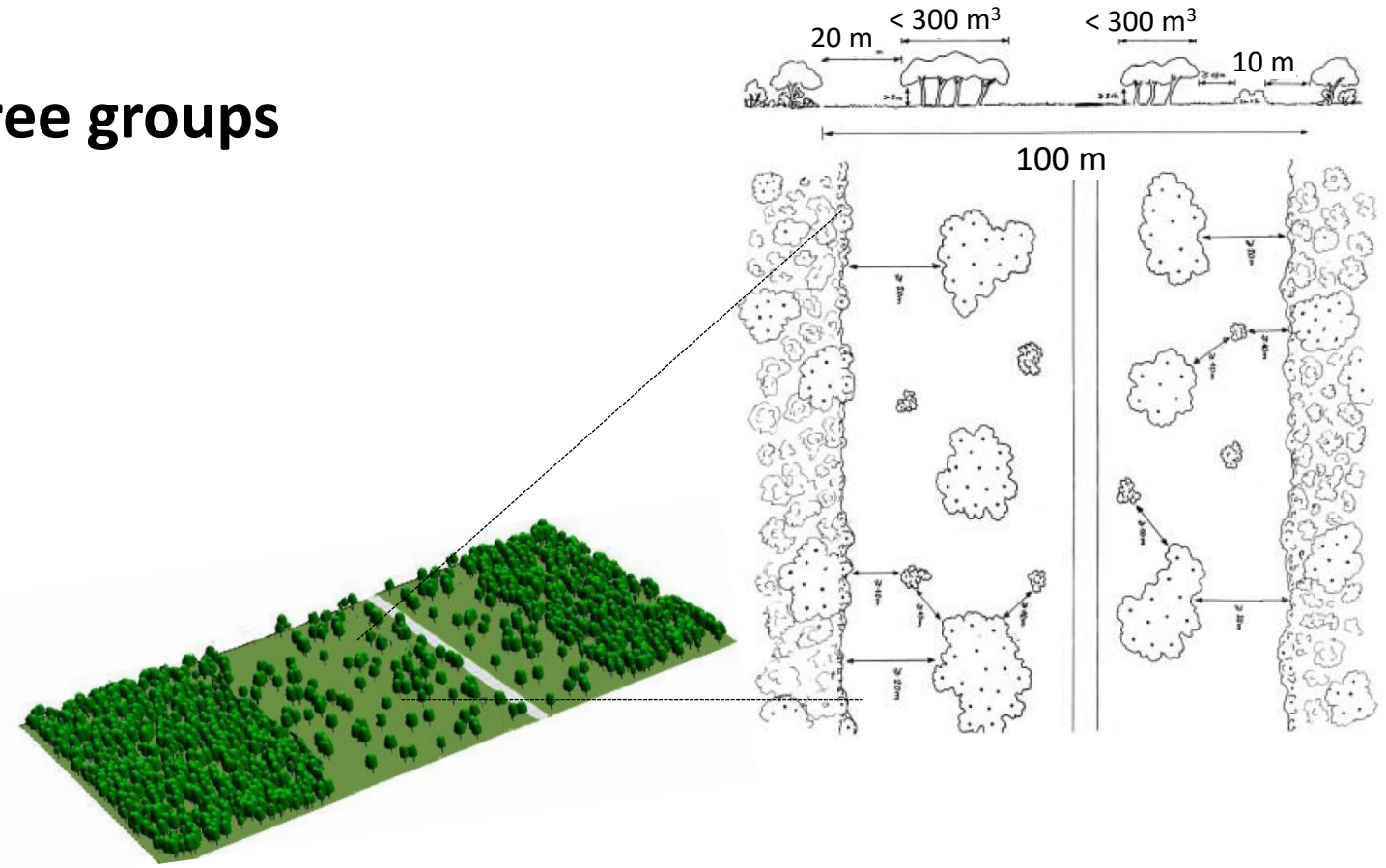
(e.g. intensity < 3000 kW/m flame length < 3m)

Stand scale: infrastructures to increase fire fighting capacity and safety

Prescriptions

Shaded fuel breaks with **tree groups**

- density < 150 tree/ha + volume group < 300 m^3
- group distance (> 20 m)
- crown insertion > 6 m
- surface fuels < 4-8 t/ha
- no decaying trees
- few dead trees and deadwood



Rigolot É., Costa M. (coord.). *Conception des coupures de combustible.* Réseau Coupures de combustible RCC n°4 - Éd. de la Cardère Morières, 2000, 154 p.

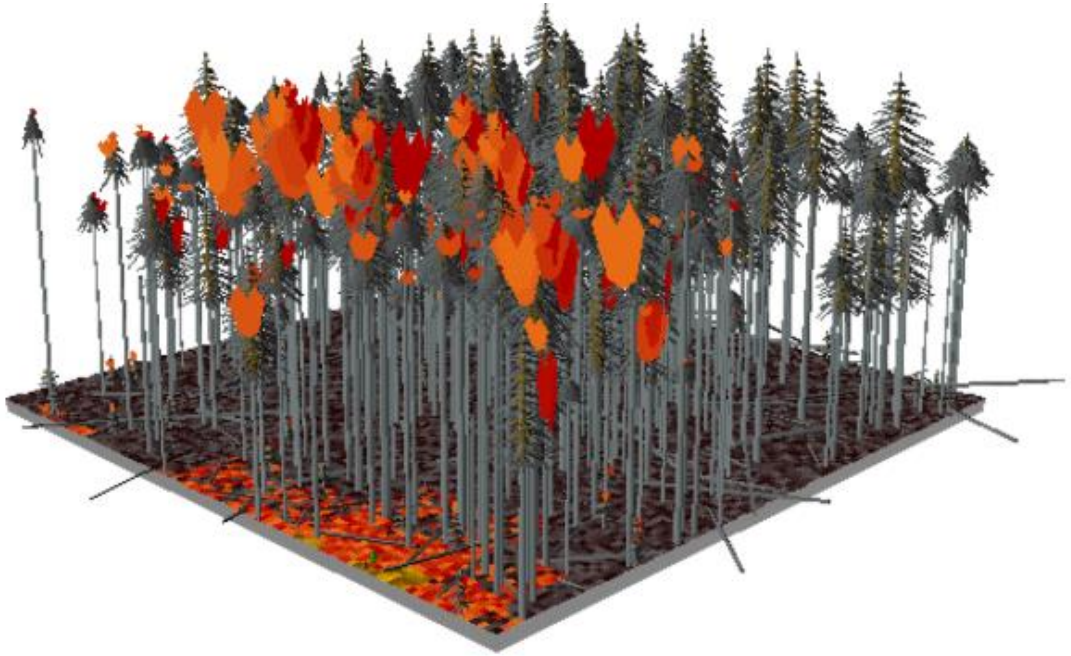
Stand scale: infrastructures to increase fire fighting capacity and safety

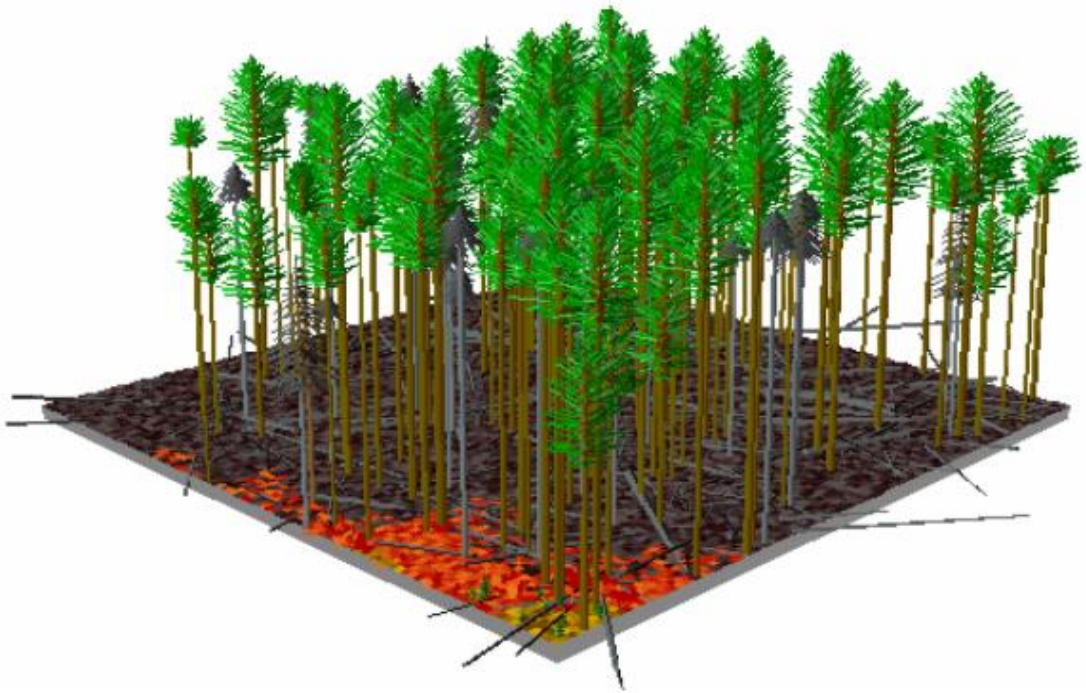
Example: shaded fuel breaks network in the Merse ZCS IT5190006-07

Shaded fuelbreaks
Standards for fire-fighters safety **have priority** over other needs.
It may be necessary to **deviate** from **forest regulation (e.g. specific ZCS conservation measures)** within the fuelbreak (basal area, tree cover, deadwood retention, habitat trees)

Pyro-silviculture to increase stand self-resistance

Increase the **resilience properties** of the population and **mitigate** the **potential fire behavior** so that the **flame front intensity is below** the **resistance** threshold of the tree individuals





Pyro-silviculture to increase stand self-resistance

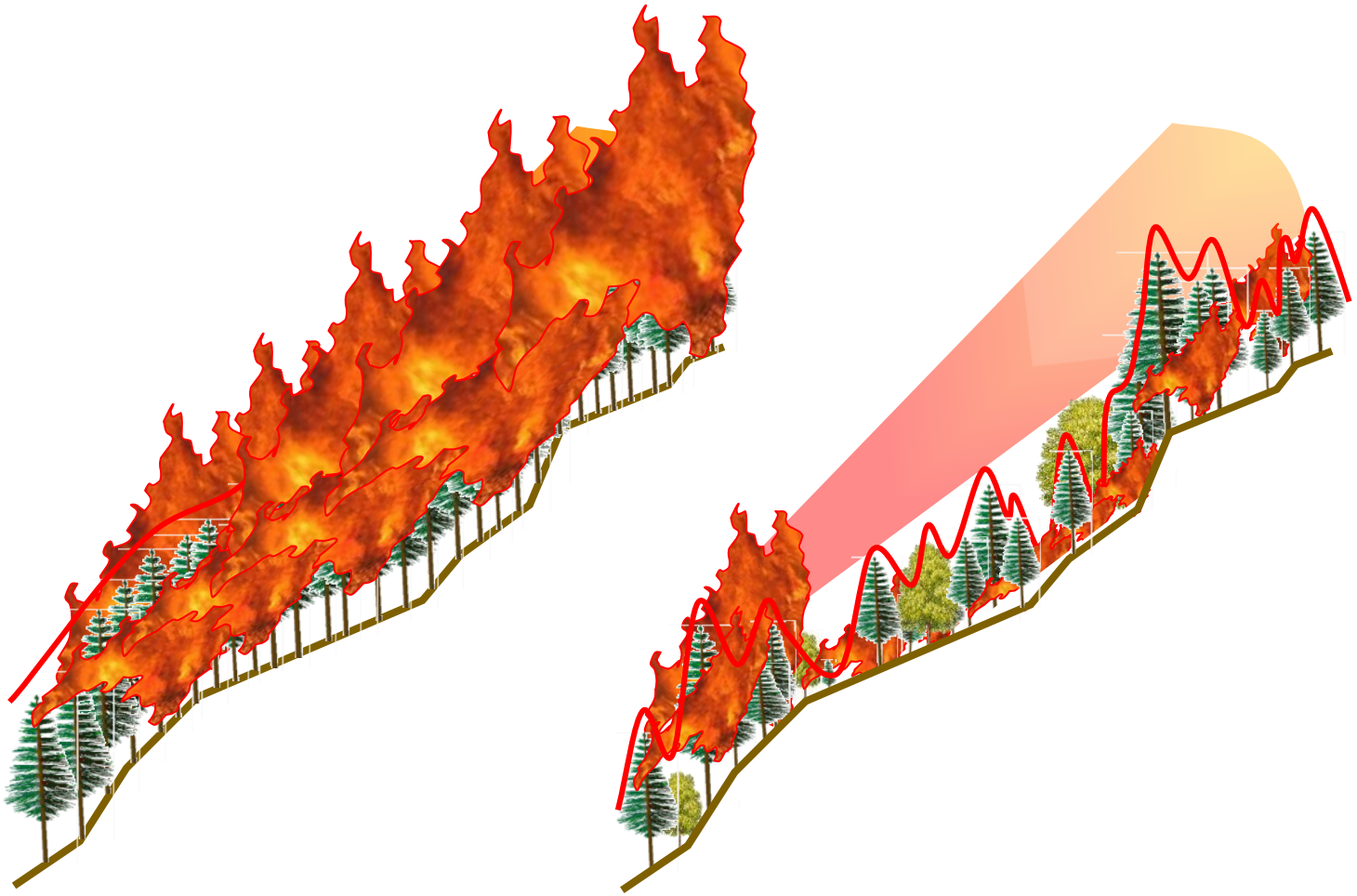
Pyro-silviculture to increase stand self-resistance

Photo: Motta

Closer-to-nature approach

Observation of the structure of **fire-prone stands** to understand the elements that **confer resistance** and resilience to fires and development of **pyro-silvicultural** modules that **mimic** fire resistance stand **characteristics**

Pyro-silviculture to increase stand self-resistance

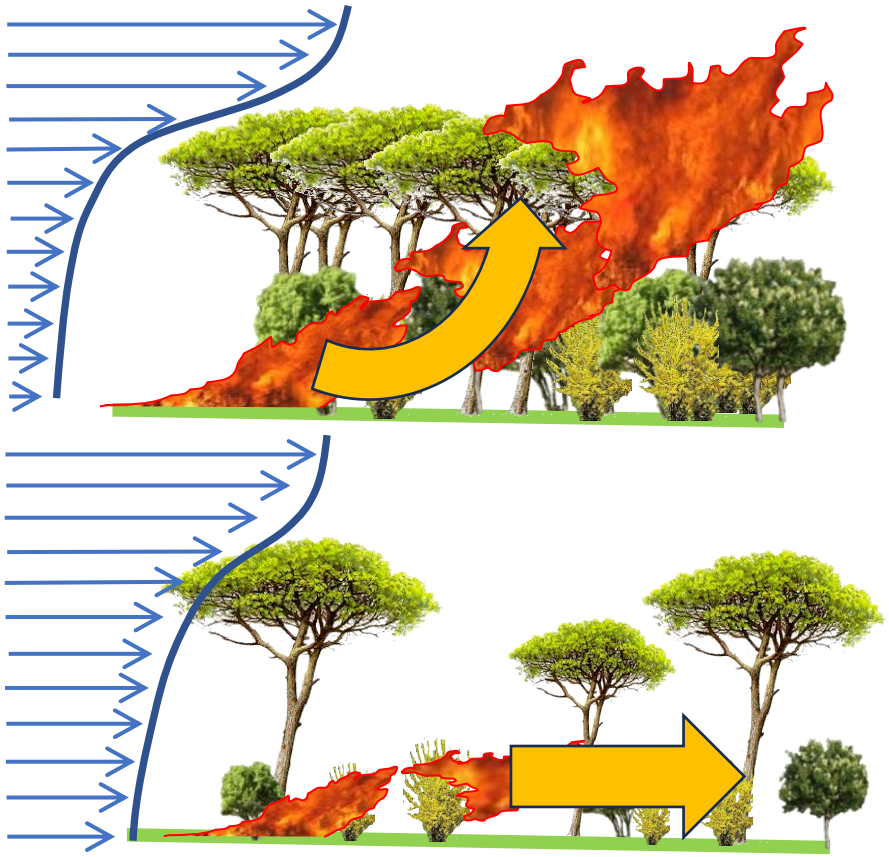


Closer-to-nature approach

Understanding the interaction between the **forest structure** and the **physics of fire**,

i.e. disrupting the alignement between the **convection of hot air** that pre-heat upslope crowns, and biomass available for burning; changing flammability properties of the biomass

Pyro-silviculture to increase stand self-resistance



Convective Cooling - -

Convective Cooling + +

Closer-to-nature approach

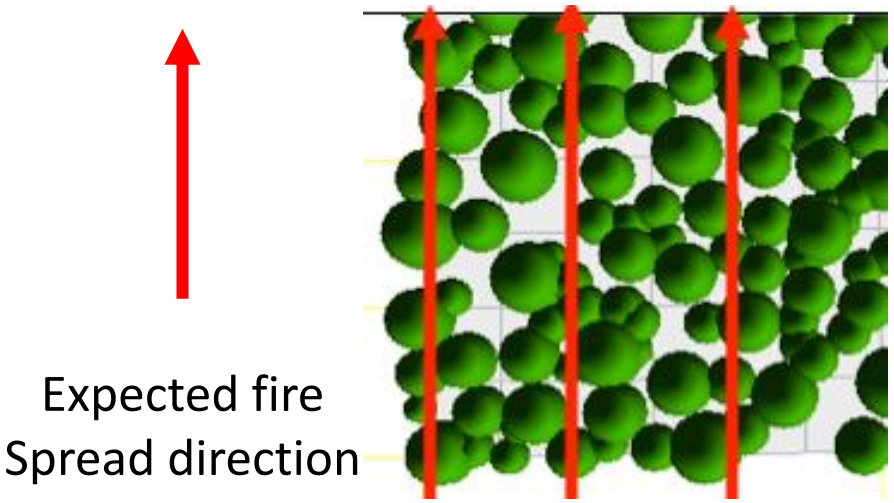
Understanding the interaction between the **forest structure** and the **physics of fire**,

i.e. **wind flow** through crowns, **convection of hot air** that pre-heat upslope crowns,increased wind speed that **dipserses** heat, **convective cooling** due upslope air attracted by fire

Pyro-silviculture to increase stand self-resistance: e.g. dry conifers

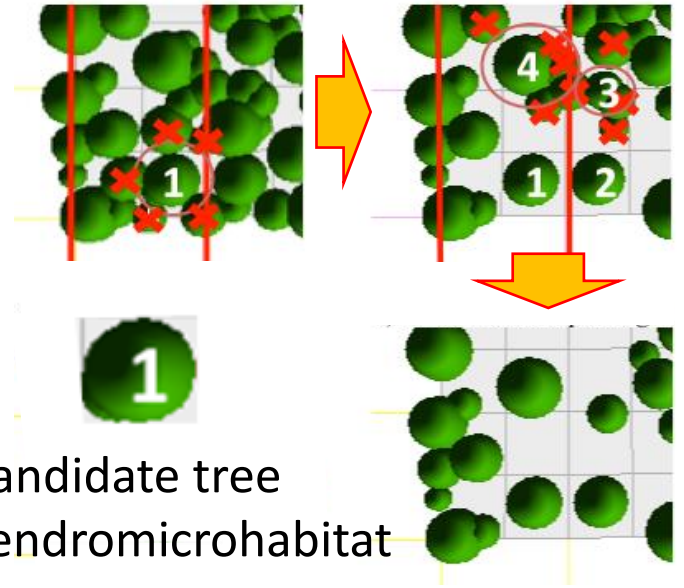
Pyro-silviculture to increase stand self-resistance

Evaluate the **resistance traits** of trees and their **flammability** in relation to **neighboring trees** and expected fire **spread direction**, especially with species that support **crown fires**



Modified from Cantiani P.

Retain resistant trees (e.g., large DBH, thick bark, stable), **selecting** for cutting individual **trees** or **groups** around **candidate plants** to avoid the contagion of **crown fire** or **lethal thermal doses** to candidates

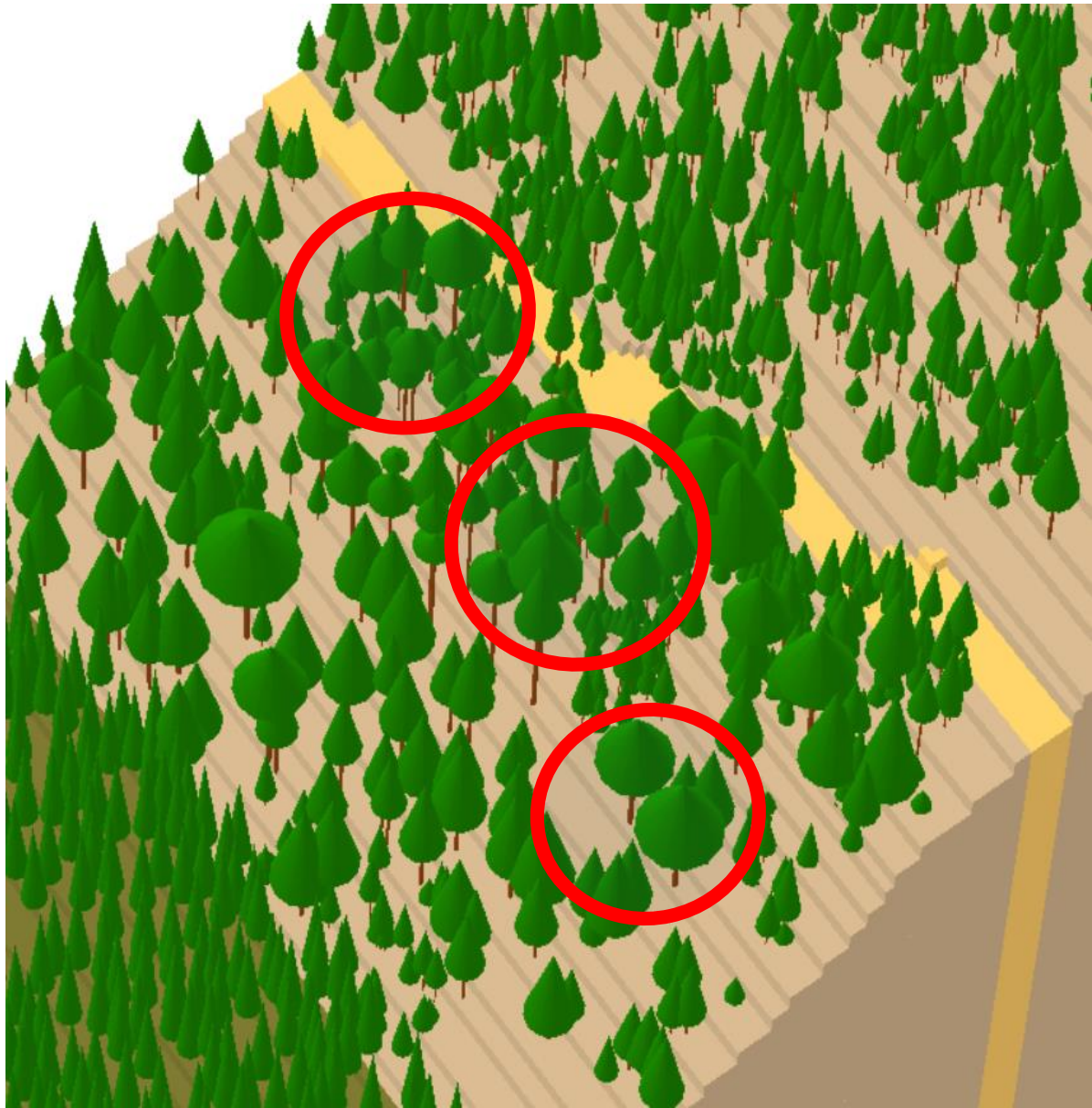


Pyro-silviculture to increase stand self-resistance

Around the **candidate trees** and **groups** the pyro-sivicultural module creats a system of **1st** and **2nd order gaps**.

The 1st-order gaps are **2-3 times** the **tree height** in the **direction** of expected fire propagation (wind x slope) and 1-2 times the tree height in **width**.

The 2nd-order gaps are **1-2 times** the **tree height** directed **perpendicular** to the 1st-order gaps.



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Pyro-silviculture to increase stand self-resistance

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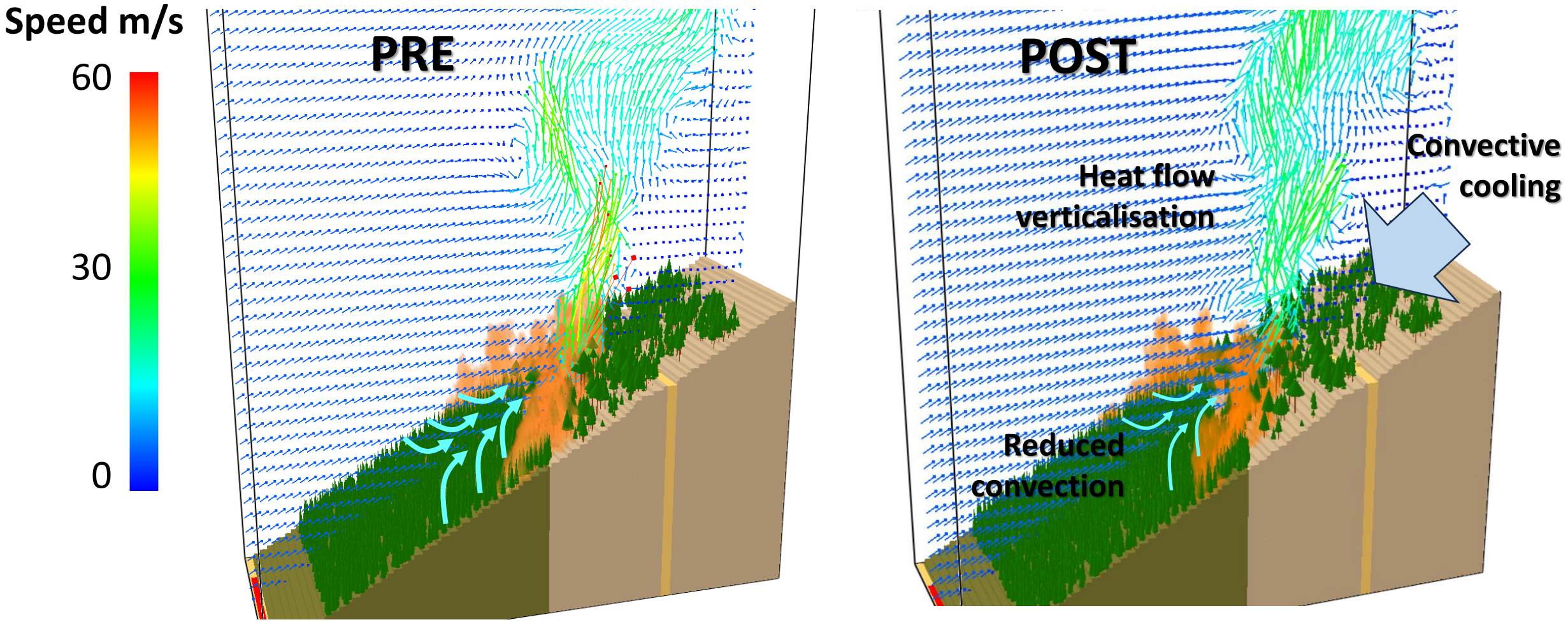
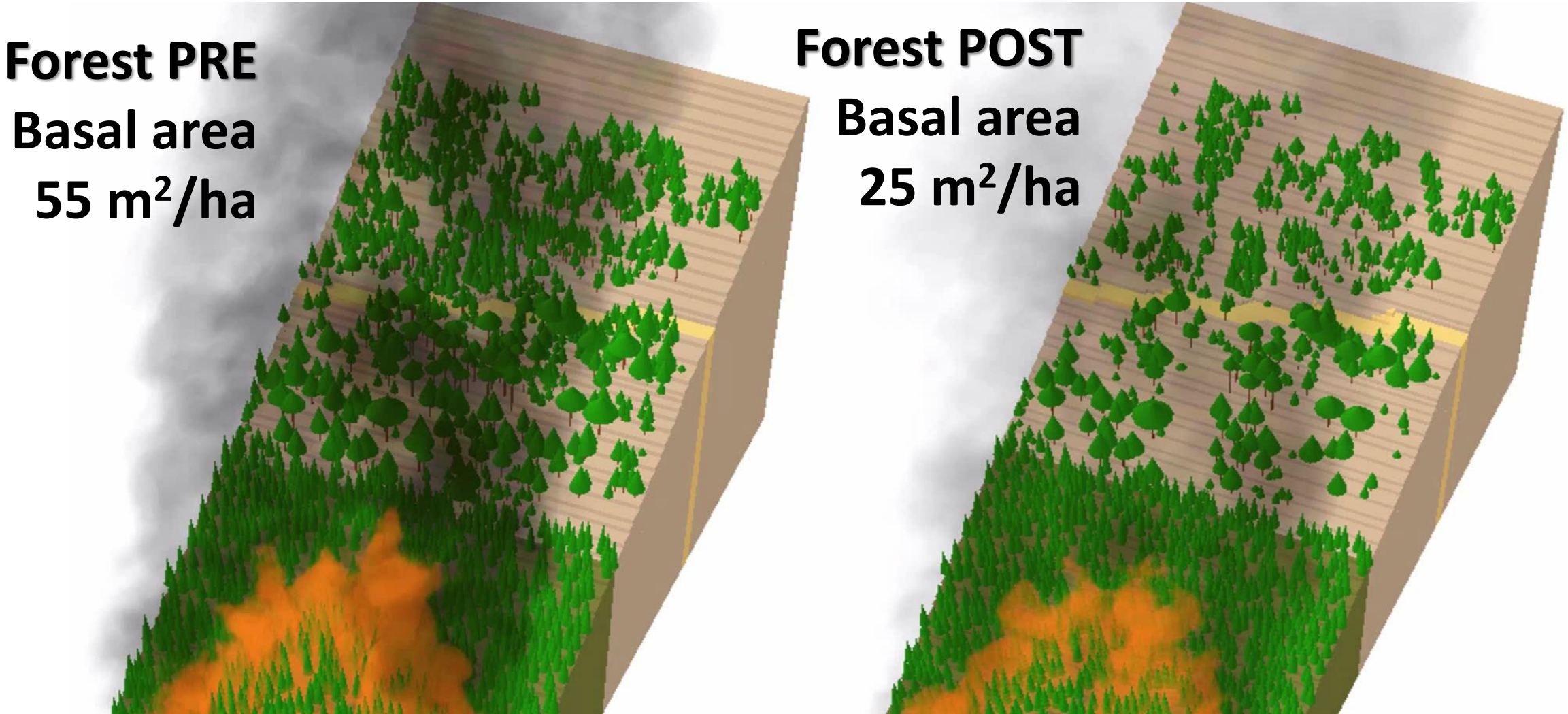
Pyro-silviculture to increase stand self-resistance

Changes in **convection**, **heat flow** intensity and **direction**, **convective cooling**



Pyro-silviculture to increase stand self-resistance

Changes in **crown consumption** and **disruption** of the **crown fire** propagation



Pyro-silviculture to increase stand self-resistance

Example of **variable retention harvest** in a **dry conifer forests** in Italy,
e.g. group selection, gap network according to expected fire direction

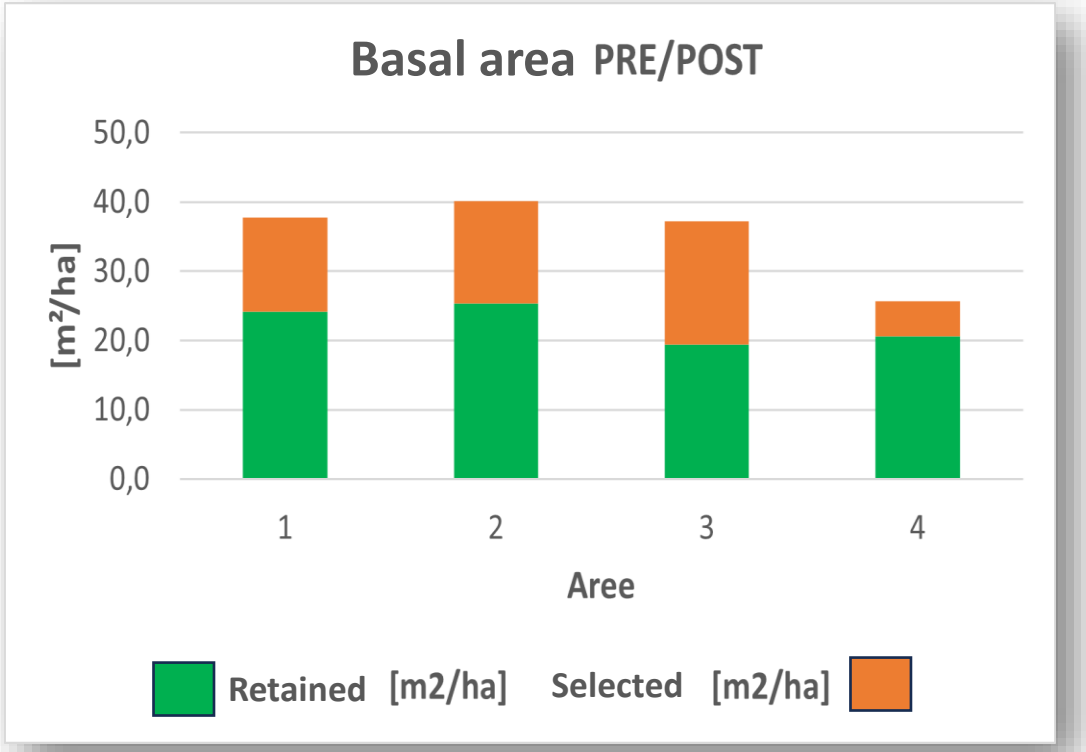
Photo: *Renzo Motta, UNITO*

Pyro-silviculture to increase stand self-resistance

Example of **variable retention harvest** in a **dry conifer forests** in Italy

Post-treatment changes in the **forest structure** in **4 experimental areas** (1 ha)

Post-treatment	Area 1	Area 2	Area 3	Area 4	Mean
Trees/ha selected [%]	40,0	44,6	53,2	24,4	**40,6**
Piante/ha retained [n/ha]	637	385	297	205	**381**
G/ha selected [%]	35,9	36,7	47,8	19,4	**34,9**
G/ha retained [m²/ha]	24	25	19	21	**22**
V/ha selected [%]	35,0	35,4	46,4	17,9	**33,7**
V/ha retained [m³/ha]	193	193	151	206	**186**

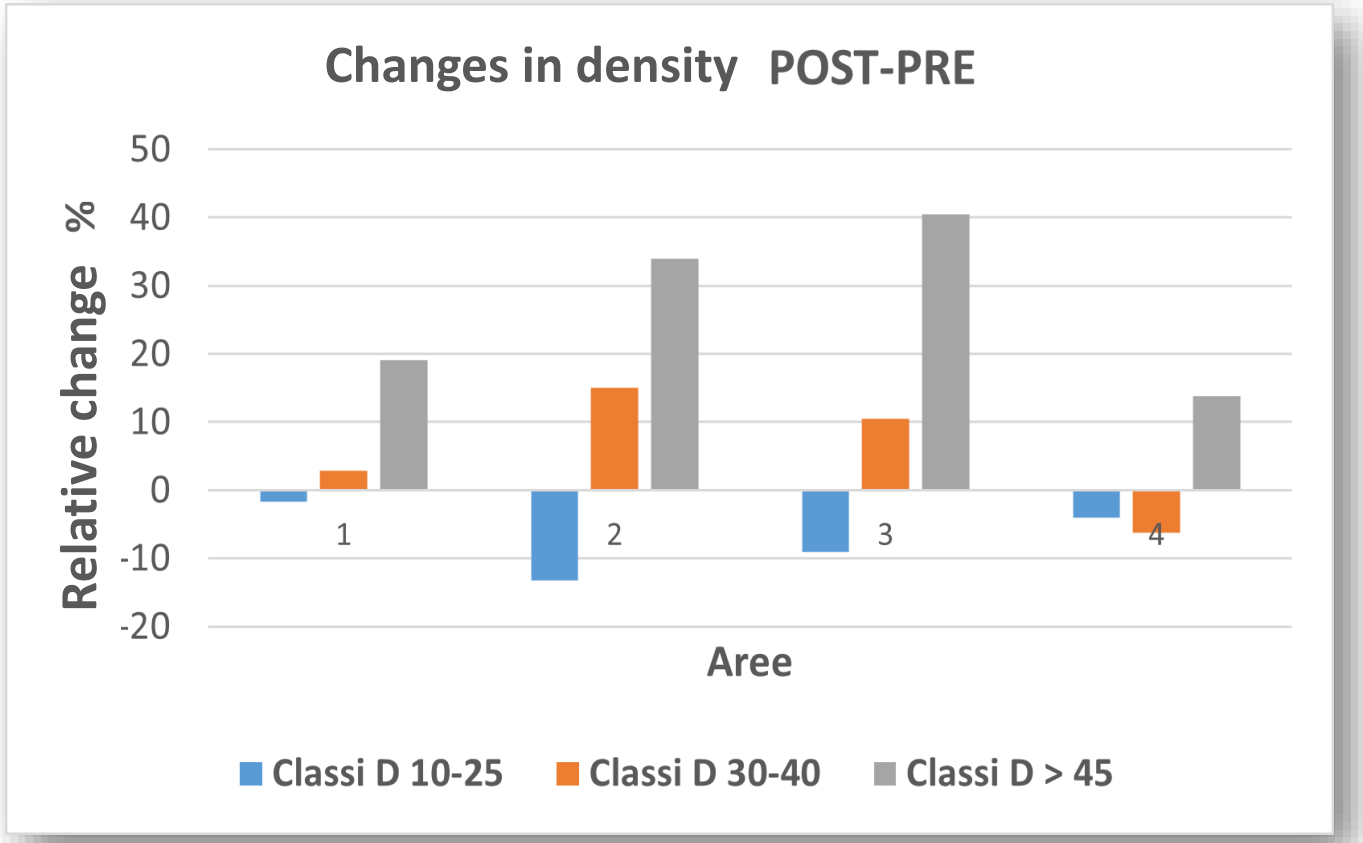


Pyro-silviculture to increase stand self-resistance

Example of **variable retention harvest** in a **dry conifer forests** in Italy

Post-treatment changes in the **forest structure** in **4 experimental areas** (1 ha)

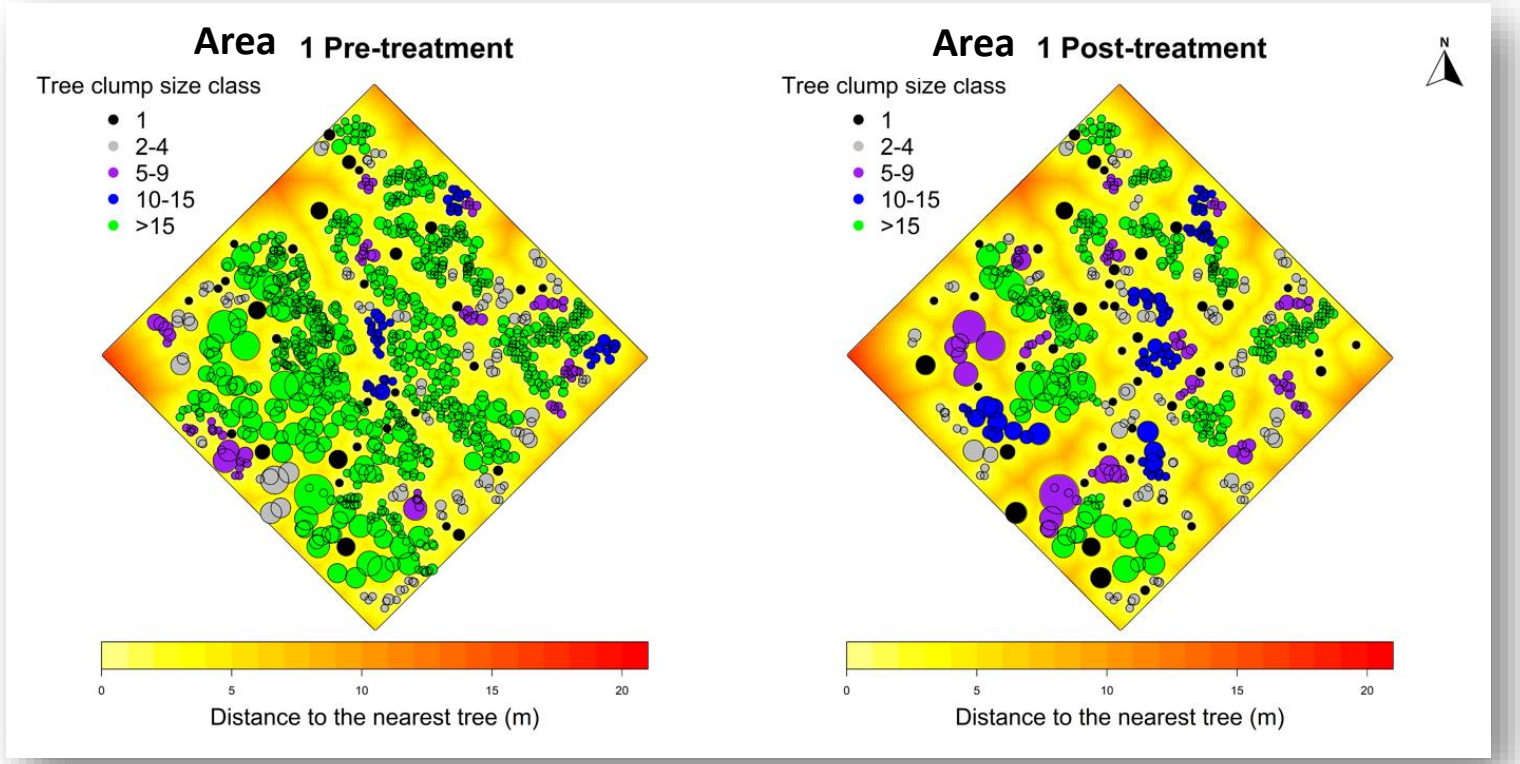
- Increase % **resistance traits** to **fire**:
  - Decrease % trees in **classes D 10-25**
  - Increase % trees in **classes D≥45 cm**

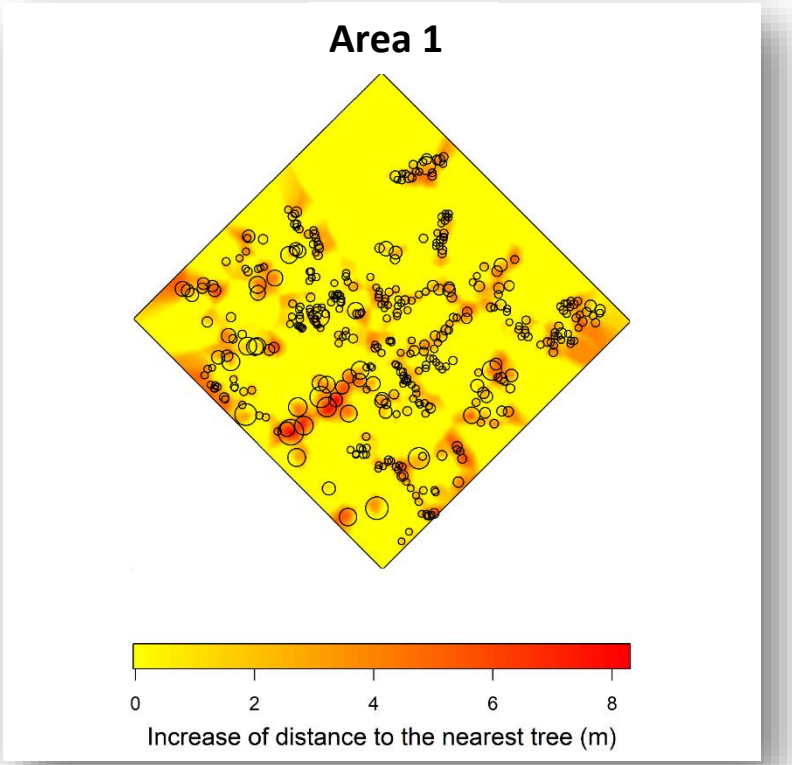


Pyro-silviculture to increase stand self-resistance

Example of **variable retention harvest** in a **dry conifer forests** in Italy

Change in the spatial distribution of groups (and size) between pre- and post-treatment scenarios with **reduction of very large groups**

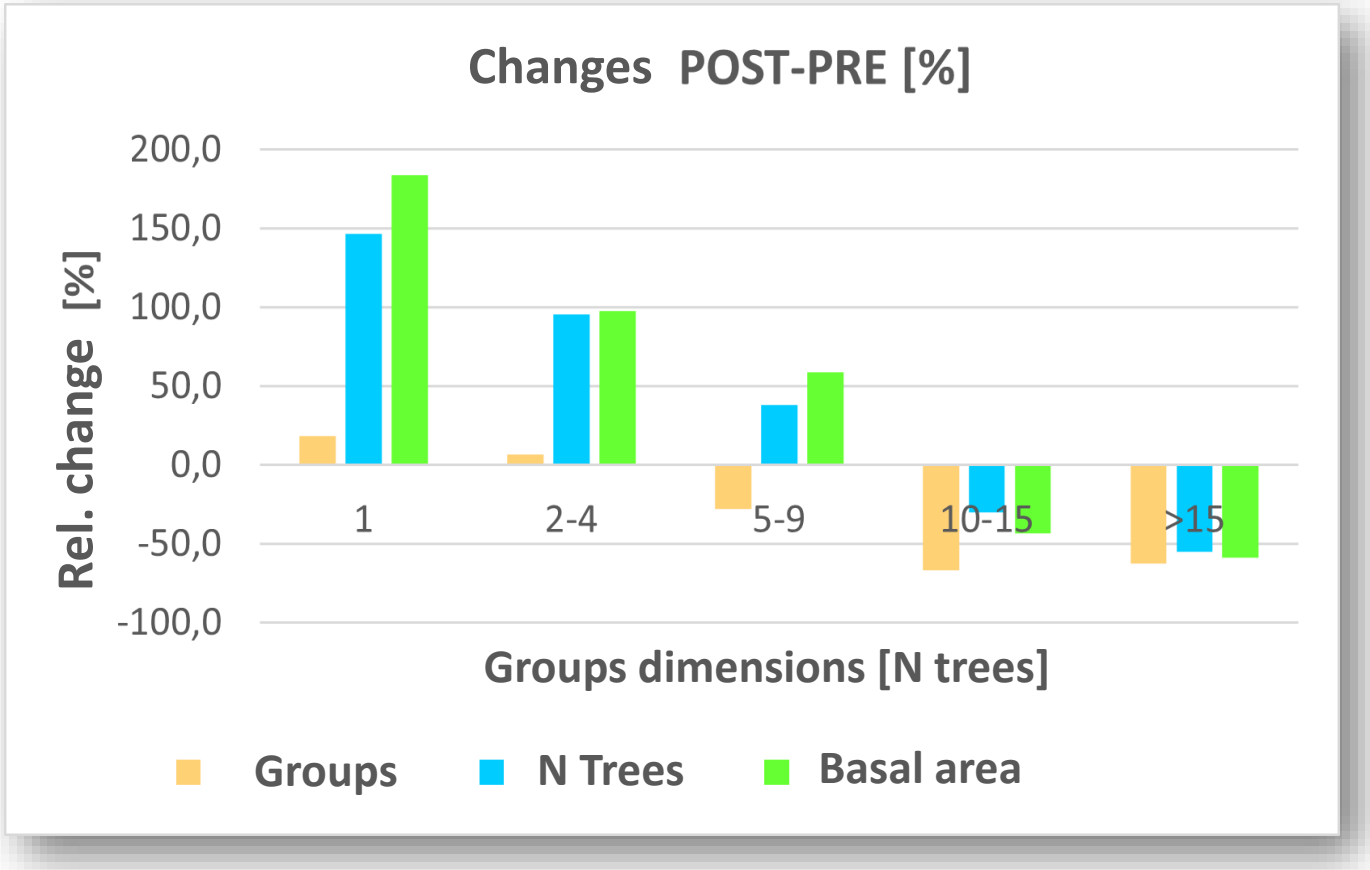




Pyro-silviculture to increase stand self-resistance

Change in the spatial distribution of groups (and size) between pre- and post-treatment scenarios with **reduction of very large groups**

- **Reduction** large groups
- Increase **distribution %** of basal area in groups of **minor dimensions**



Pyro-silviculture to increase stand self-resistance

Pyro-silvicultural modules are **complemented** by **surface fuels treatments** that modify the **flammability** of the understory using various techniques such as mechanical shredding, prescribed burning, or prescribed grazing

Mechanical

Prescribed burning

Prescribed grazing

Thanks for the attention