Surface and crown fire regimes in the western Mediterranean: the role of plant trait strategies and conditional factors

Costa-Saura J.M.[1, 2,3], **Ottaviani G.**[2,4] , **Sirca C.**[1, 2,3] **& Spano D.** [1, 2,3]

[1] *University of Sassari (UNISS), Department of Agricultural Sciences, Sassari, Italy*
[2] *National Biodiversity Future Center (NBFC), Palermo, Italy*
[3] *Foundation Euro-Mediterranean Center on Climate Change (CMCC), Sassari, Italy*
[4] *Research Institute on Terrestrial Ecosystems (IRET), National Research Council (CNR), Porano, Italy;*

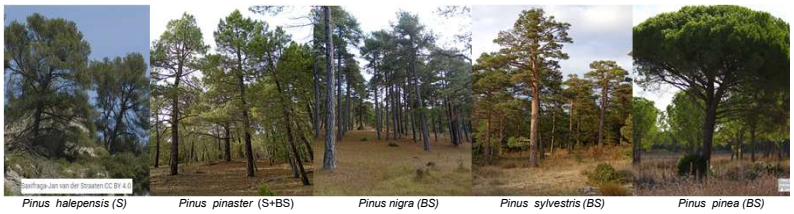
Fire regimes vary widely across ecosystems, with one critical distinction occurring between surface and crown fires. This difference is crucial, as it strongly influences ecosystem dynamics and appropriate strategies for wildfire risk management. Climate change is expected to alter fire regimes by intensifying warming and drying trends and by modifying species distributions. Within this context, plant functional traits play a central role. They not only respond to environmental filtering but also actively shape ecosystem processes. Two traits in particular— **branch shedding [BS]** (the ability to shed dead lower branches) and **serotiny [S]** (the retention of mature cones that open only after exposure to high temperatures)—have been proposed as key adaptive strategies influencing fire regimes. However, the extent to which these traits are associated with specific fire types, and how this relationship depends on forest structural and environmental conditions, remains insufficiently understood. Thus, putting the focus on five native Iberian pine species, which collectively represent the dominant coniferous components in the western Mediterranean, we tested if:

1. Crown fires occur more frequently in fire-embracer species (i.e., serotinous and/or not branch shedding) than in species that rely on fire-resistance strategies.

2. The effectiveness of fire-resistance strategies increases with stand development (i.e., in late successional stages).

3. The presence of ladder fuels reduces the effectiveness of fire-resistance strategies to avoid crown fires.

4. Extreme dry conditions diminish the effectiveness of fire-resistance strategies



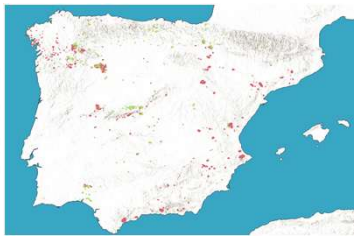
Pinus halepensis (S) *Pinus pinaster (S+BS)* *Pinus nigra (BS)* *Pinus sylvestris (BS)* *Pinus pinea (BS)*

Data and Methods

- Data from the 4th Spanish Forest Map (i.e. forest stand area, main species, successional stage, shrub height) were combined with remote-sensing–derived fire severity estimates from the European Forest Fire Information System (EFFIS).
- Crown fire probability was defined as the percentage of pixels classified with high/moderate high severity within the forest stand.
- SPI values were calculated for each stand using ERA5 land data within Google Earth Engine
- The effect of fire strategies on crown fire probability was tested using linear models that accounted for the potential influence of successional stage, shrub height, and dryness during the fire season.

Class	dNBR range (multiplied by 1000)
Unburned or Regrowth	< 100
Low severity	100 - 270
Moderate low severity	270 - 440
Moderate high severity	440 - 660
High severity	>=660

EFFIS severity data based on Sentinel 2

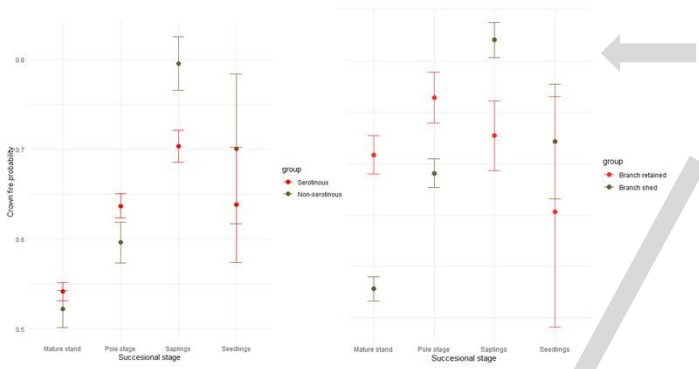


Forest stands burned during the period 2018-2024

Results

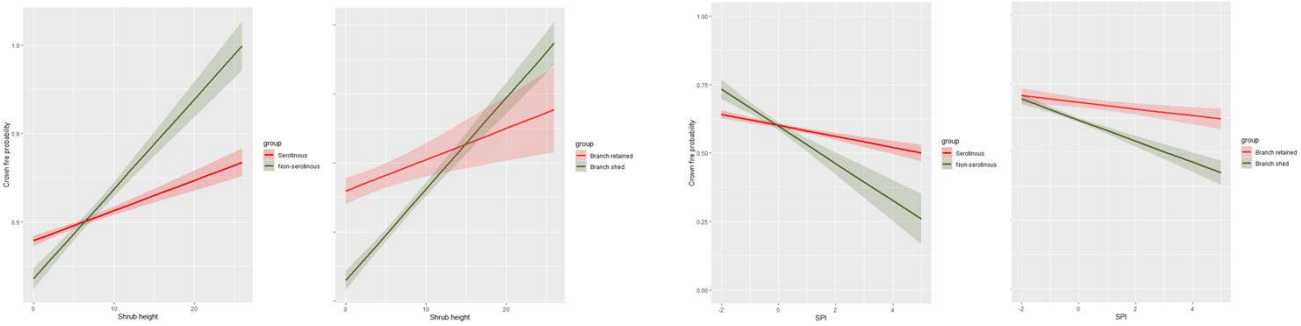
Results show that crown fire probability depends on fire strategies with the combined effects of stand structure and fire weather conditions.

- At later successional stages (i.e., *mature* and *pole stages*), crown fire probability is significantly lower than in younger stages for both non-serotinous and branch-shedding species. Serotinous species follow a similar pattern, whereas branch-retaining species exhibite less marked differences across developmental stages.
- Leader fuels increase crown fire probability specially in stands dominated by fire resistance/avoidance species.
- Crown fire probability increase with extreme dry conditions (negative SPI) specially in stands dominated by fire resistance/avoidance species.



Conclusions

- Potential warmer and drier future conditions may threaten the effectiveness of fire resistance strategies.
- When designing adaptation actions inspired on fire strategies, stand characteristics should be considered to ensure the excepted success.



2nd International Symposium on Biodiversity and Ecosystem Functions under Global Change
12 – 14 November 2025
Alghero (Sardinia – Italy)