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SAMFIX
SAving Mediterranean Forests from Invasions of Xylosandrus beetles and associated pathogenic fungi

ENVIRONMENTAL, BIOLOGICAL AND HUMAN DRIVERS OF THE DIEBACK OF AN EVERGREEN MEDITERRANEAN FOREST

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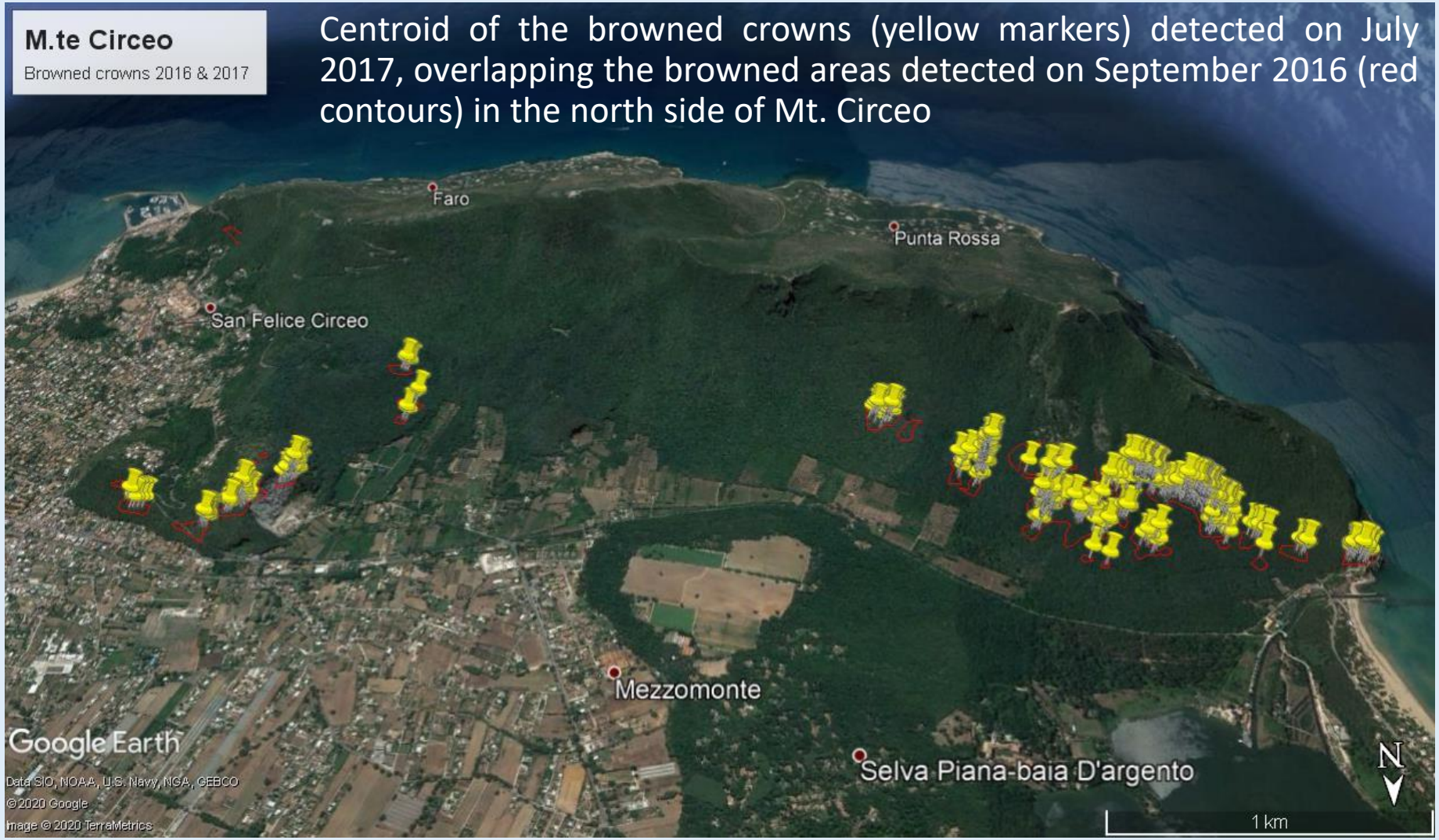
On September 2016, a diffuse browning of the crowns has been observed in the north side of promontory of Circeo (Italy). The desiccations of the upper crown twigs have been associated with the diffusion of the Asian Ambrosia beetles *Xylosandrus compactus* (black twig borer). In fact, infested trees "typically" show wilting, branch dieback, shoot breakage and general decline.



Centroid of the browned crowns (yellow markers) detected on July 2017, overlapping the browned areas detected on September 2016 (red contours) in the north side of Mt. Circeo

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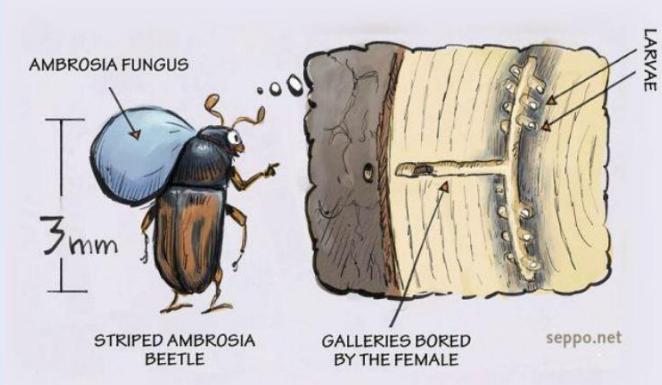
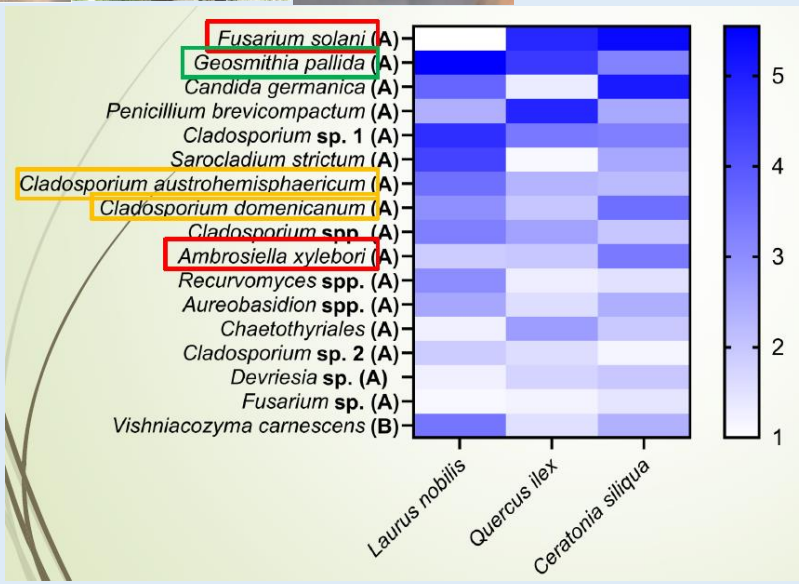
As biological drivers of the tree mortality observed in the area, the ambrosia beetle *Xylosandrus compactus* possibly played a role considering that the impact on the crown is related to both wood boring of the twigs and the introduction of ambrosia fungi, which are of crucial importance for larval development. These ambrosia fungi are often pathogenic to the host trees, and the diffusion inside the trees is frequently associated with the insect.

On the other hand the attraction of the female and the development of fungi inside the galleries are also related to the drought impacts on plant metabolism, increasing the level of complexity on spatial distribution of mortality and the consequent changes of the community structure.





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As possible environmental driver of the outbreak, the extreme drought occurred in western Europe (June 2016 - July 2017), with a peak in central Italy (where Circeo is located – see the purple arrow in figure).

According to the study of García-Herrera R *et al.* (2019), the event can be considered as the most severe European drought at the continental scale since at least 1979, and July 2016 was the driest one, breaking previous SPEI (standardized precipitation – evapotranspiration index) records by a wide margin.

Even if the relation among extreme drought events and tree mortality is modulated by the occurrence of the two main physiological effects, hydraulic failure and carbon starvation, the spread of mortality in a forest community is dependent on microenvironmental heterogeneity (soil-water, geomorphology and exposition), population structures (age-dimension, competition), spatial distribution of the woody species.

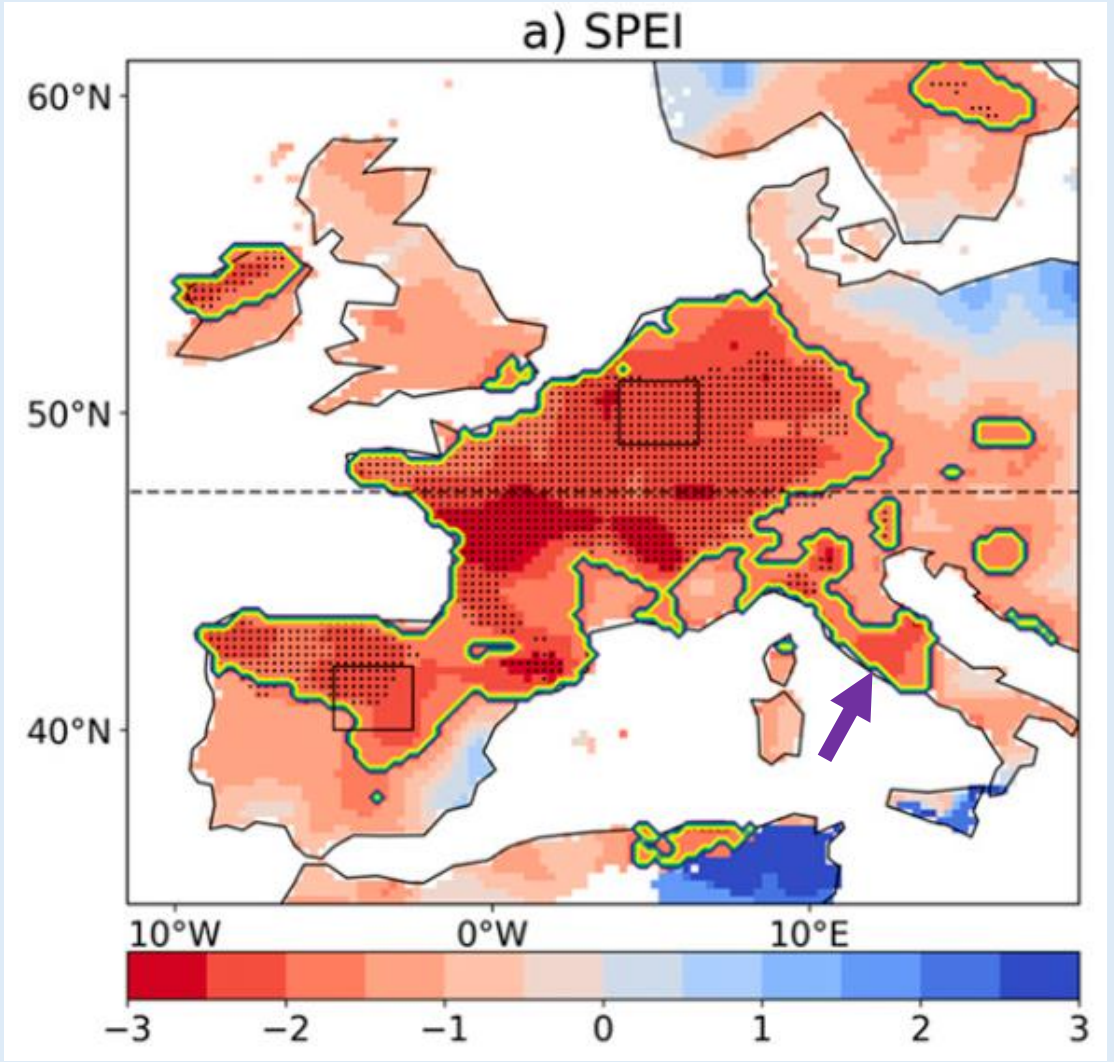

Figure from: García-Herrera R *et al.* 2019. THE EUROPEAN 2016/17 DROUGHT. *Journal of Climate* 32: 3169–3187. **DOI: 10.1175/JCLI-D-18-0331.1**

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As human factor regulating the mortality, we can consider the structure of the forest as resulting from the abandonment of the past coppice management. In fact, the original mixture of species maintained by the coppicing, is now changing mainly because the suppression of *Arbutus unedo* trees.

In the transition phase, the light competition from the upper layer dominated by Quercus ilex suppressed the codominant Arbutus (?)

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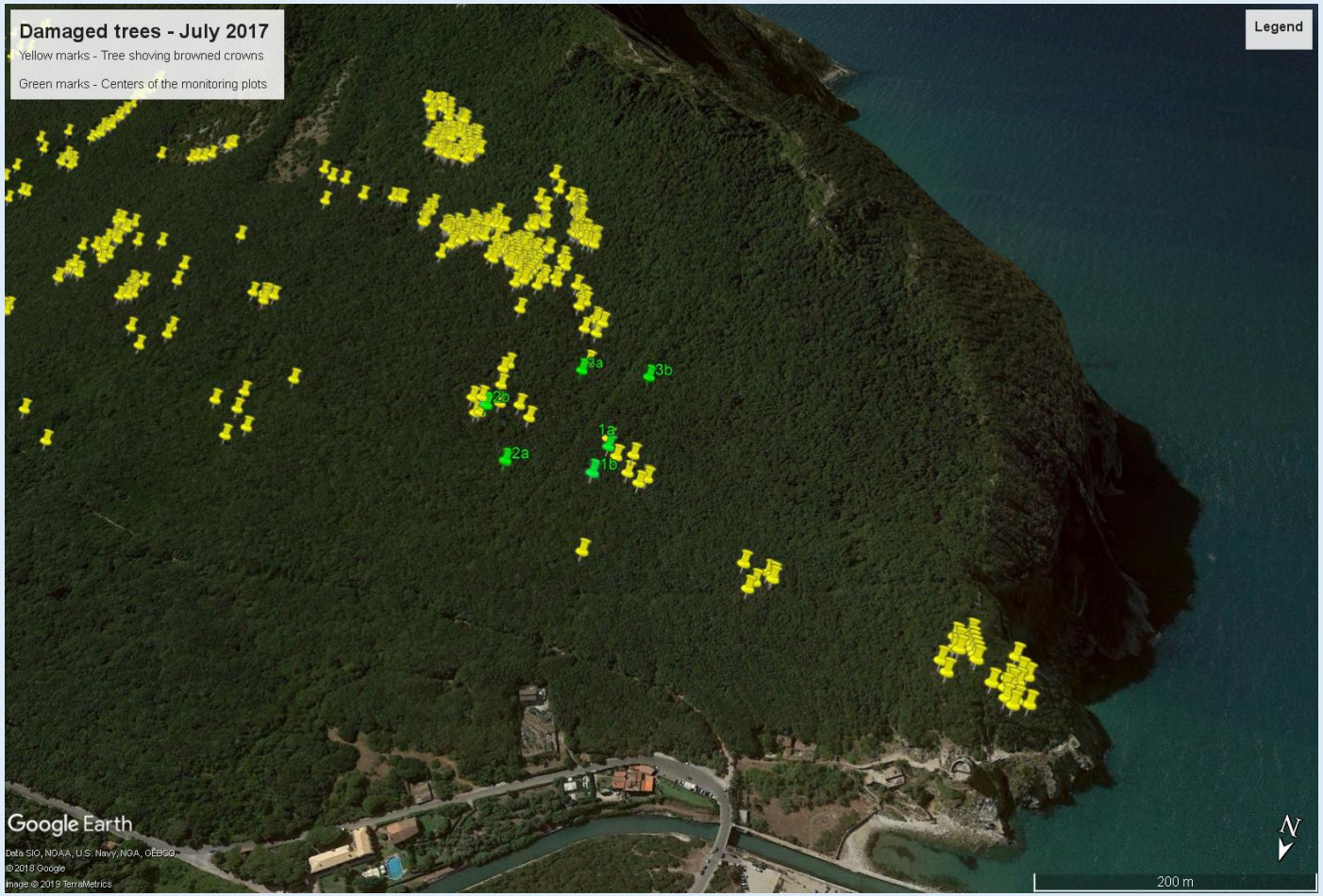
The main objective of this work was to analyse the mortality of woody plant inside patches of community, where the dominant tree were affected by the crown browning observed at end of summer 2016 and on July 2017.

3 plots have been located where at least one dominant tree showed the final symptoms of the dieback in July 2017 (yellow markers)

3 plots have been located in areas without evidence of browned crowns at the end of the drought period

Each circular plot has a diameter of 20 meters (green markers are the centre of the plots)



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In the dieback areas, the plot centres where placed in proximity of a dominant death tree (typically *Q. ilex* – multistems)

All the standing woody plants participating to the forest canopy or to the understory, within a distance from the plot centres less than 20 meters, has been classified and the DBH's measured (minimum diameter 1 cm)

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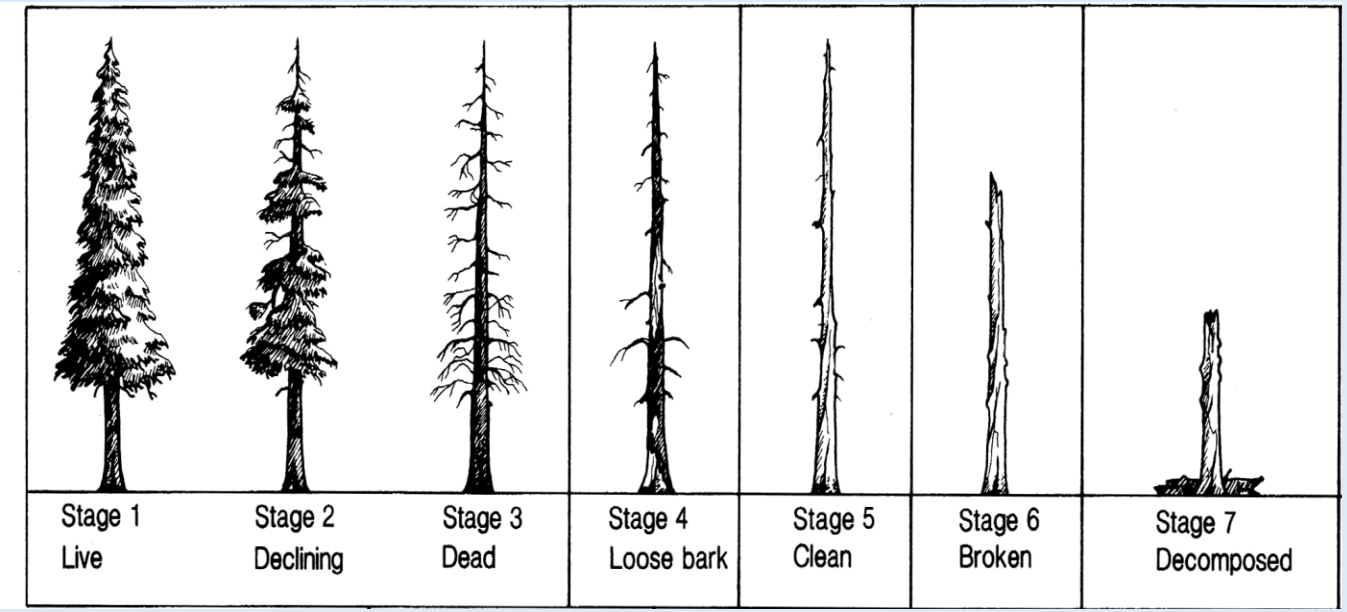

For each woody plants were recorded:

- species
- stage of dieback
- coppice shoot or standard
- diffuse epicormic shoots
- subcortical fungi stroma

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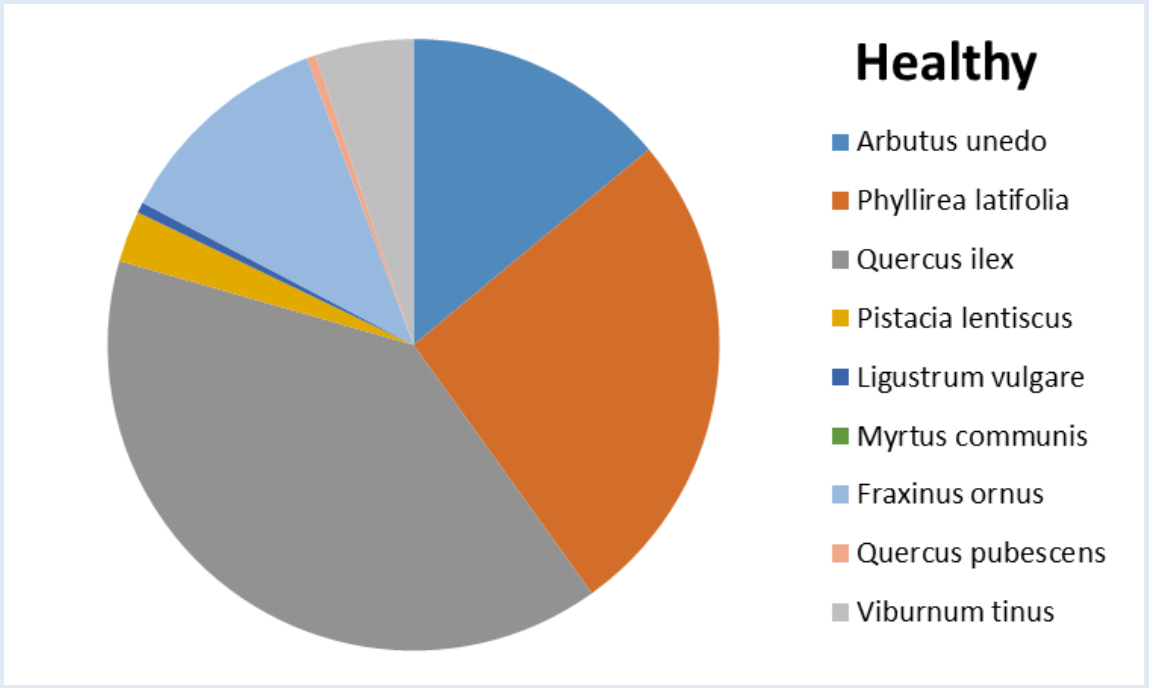
Specific structure of community: the standing stems density

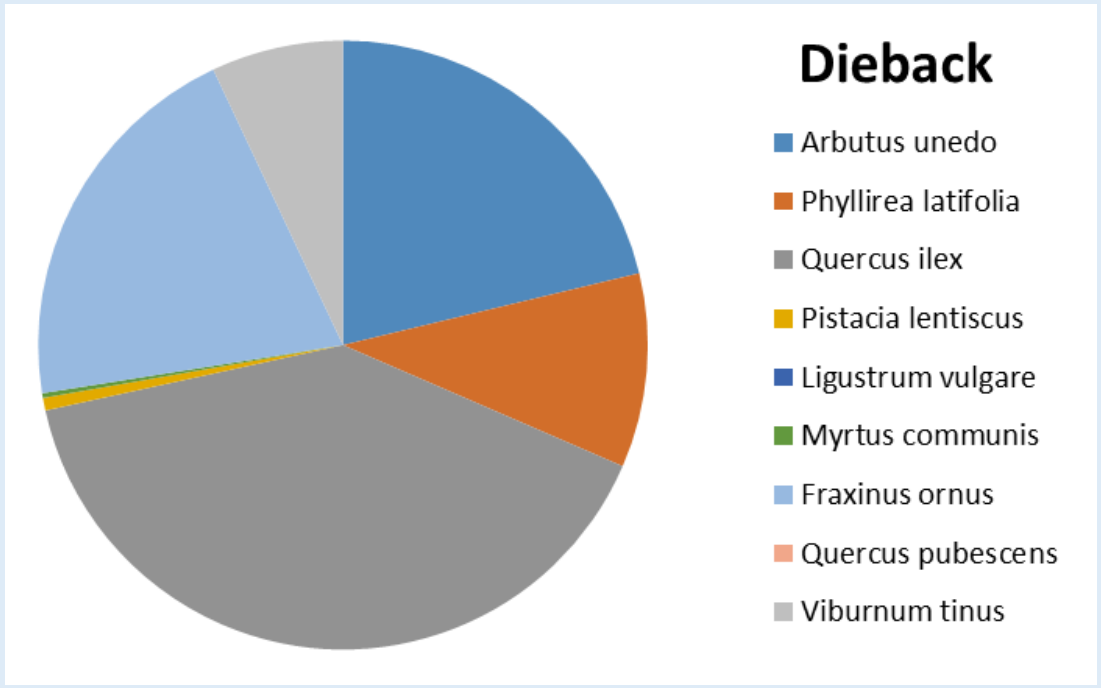
Quercus ilex **is the dominant species, while** ***Q. pubescens*** **is sporadic, in the altitudinal belt we analysed.**

Dieback plots are characterised by a lower frequency (n. of stems) of ***Phyllirea*****, counterbalanced by a relative higher frequencies of** ***Fraxinus*** **and** ***Arbutus*****.**

The frequency of ***Quercus ilex*** **(n. of stems) was practically the same in the two groups (about 40%).**

The total number of "standing" stems was slightly higher in the dieback plots.





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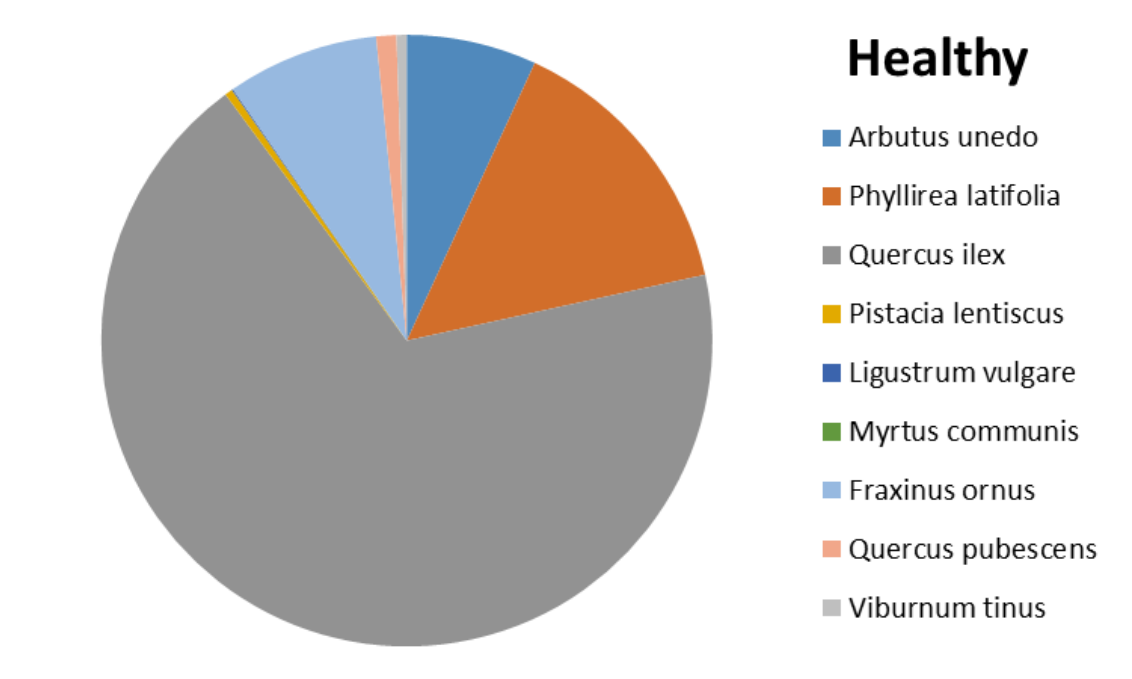
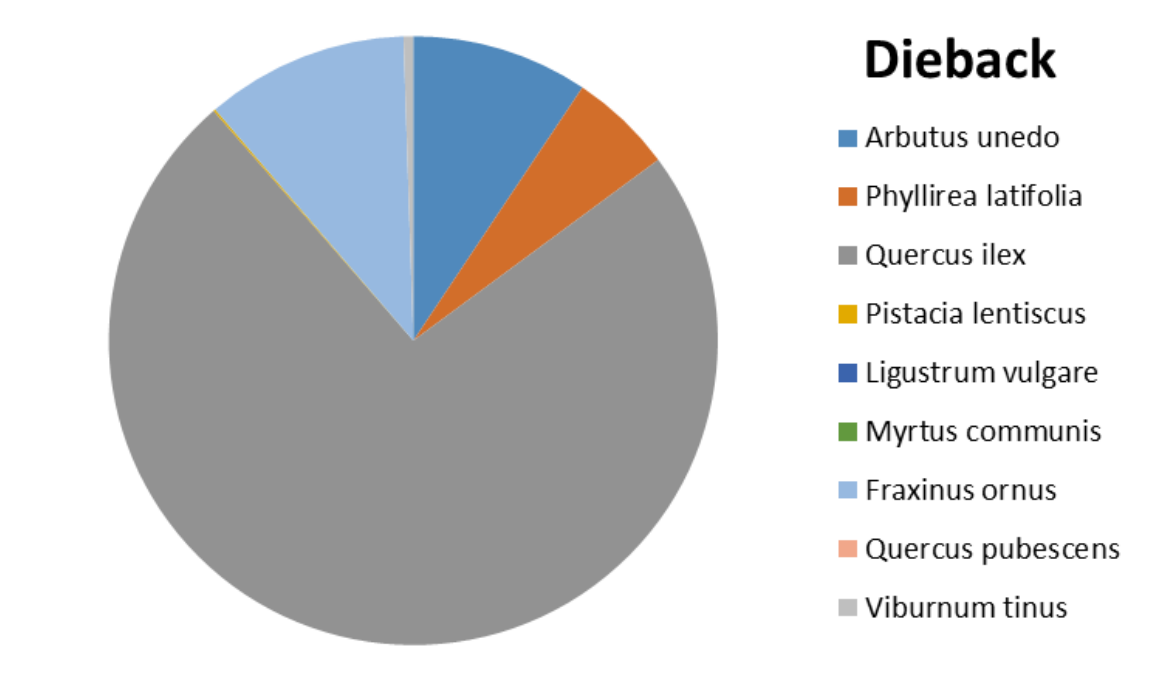
Specific structure of community: the basal area (only standing stems)

Q. ilex **is the main component of the forest stock, representing on average the 70% of the basal area (consequently dominate the wood volume and biomass).**

The reduction of *Phyllirea* in the dieback plots, is stronger when calculated on the basal area. The relative increases of both *Fraxinus* and *Arbutus* are confirmed.

As for the stem density, the basal area was slightly higher in the dieback plots.





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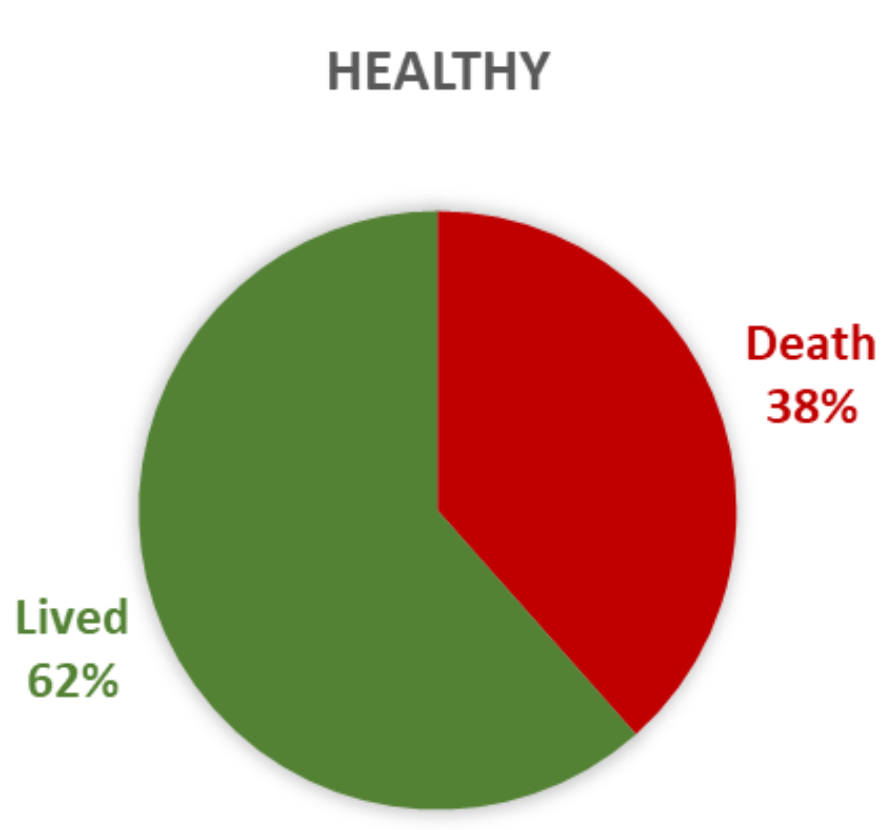
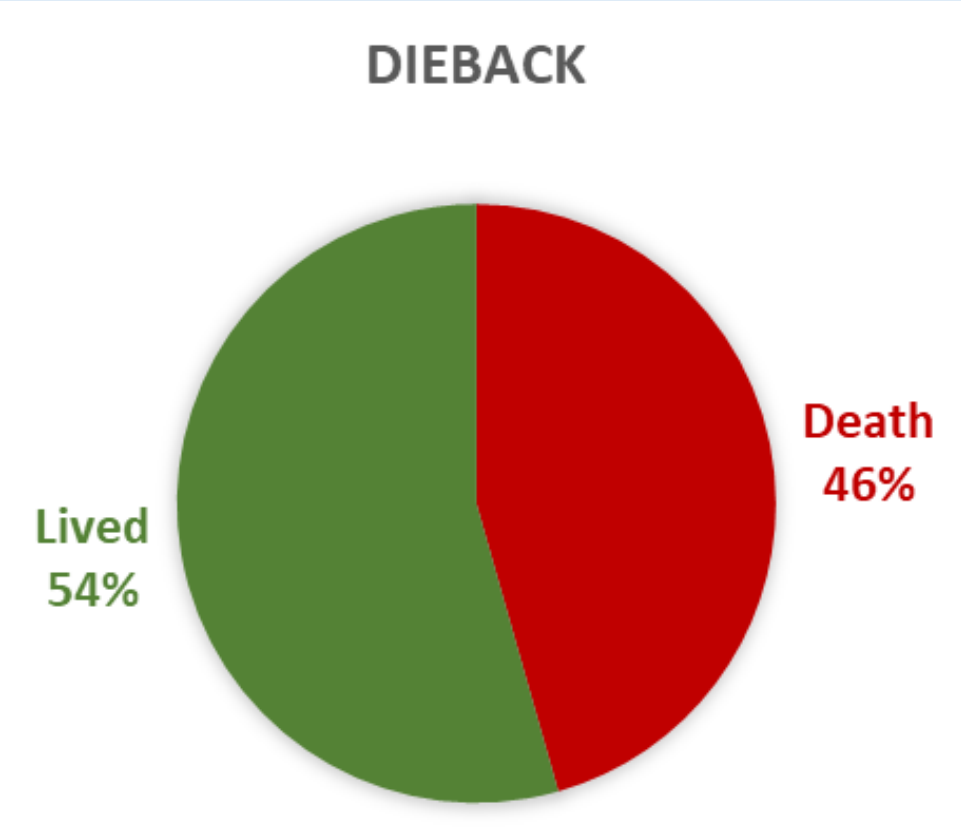
Mortality of the standing stems

(stages 3-7)

The mortality of the standing trees is quite high in both plot categories, but higher in the dieback plots





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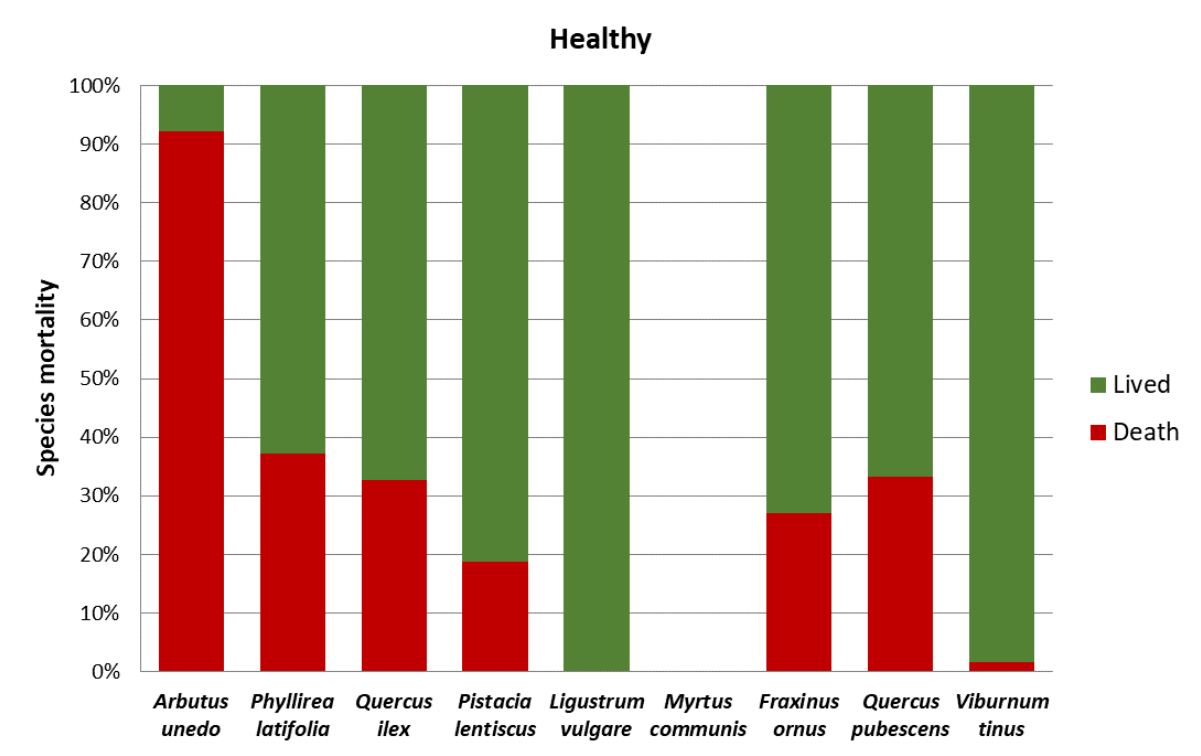
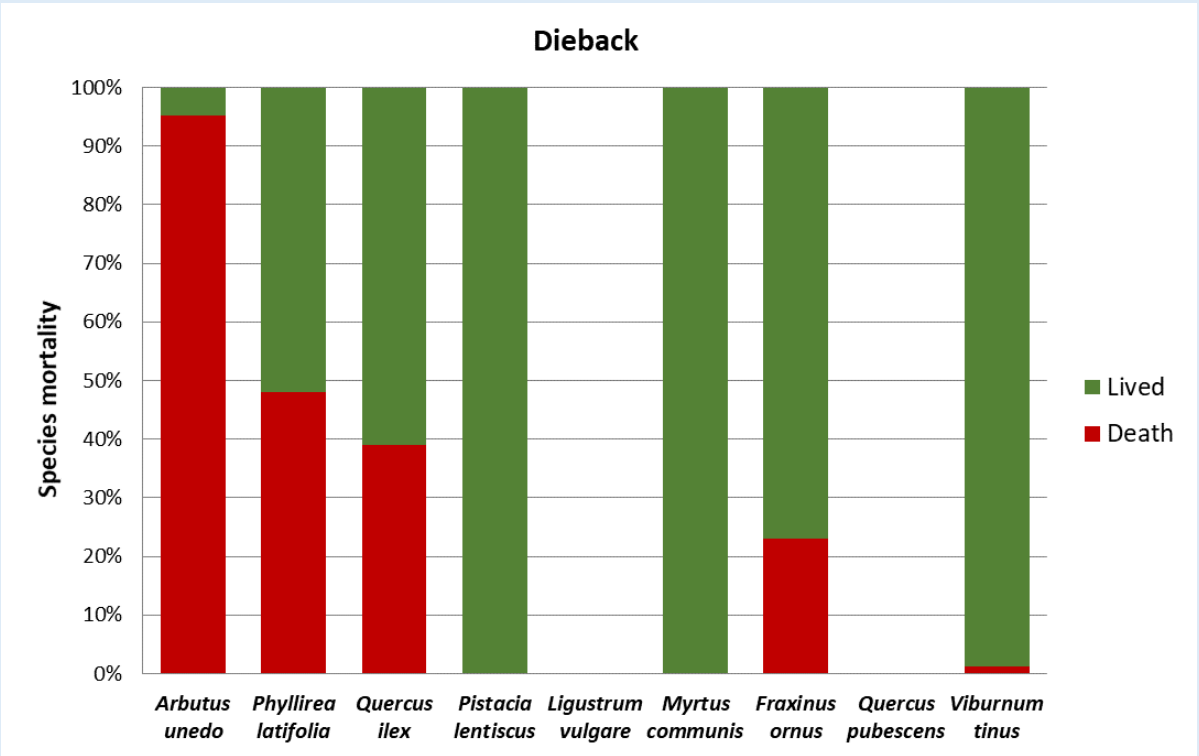
Tree species mortality - (based on standing stems density)

The few remaining standing trees of *Arbutus* are practically all deaths; *Phyllirea* is also declining as well as the *Q. ilex*, at higher rates in the dieback plots. The mortality is affecting also *Fraxinus* trees, but at a lower level (about 30%). The evergreen shrubs/small trees of the understory (*Pistacia, Viburnum, Ligustrum*) are mainly not affected by mortality.





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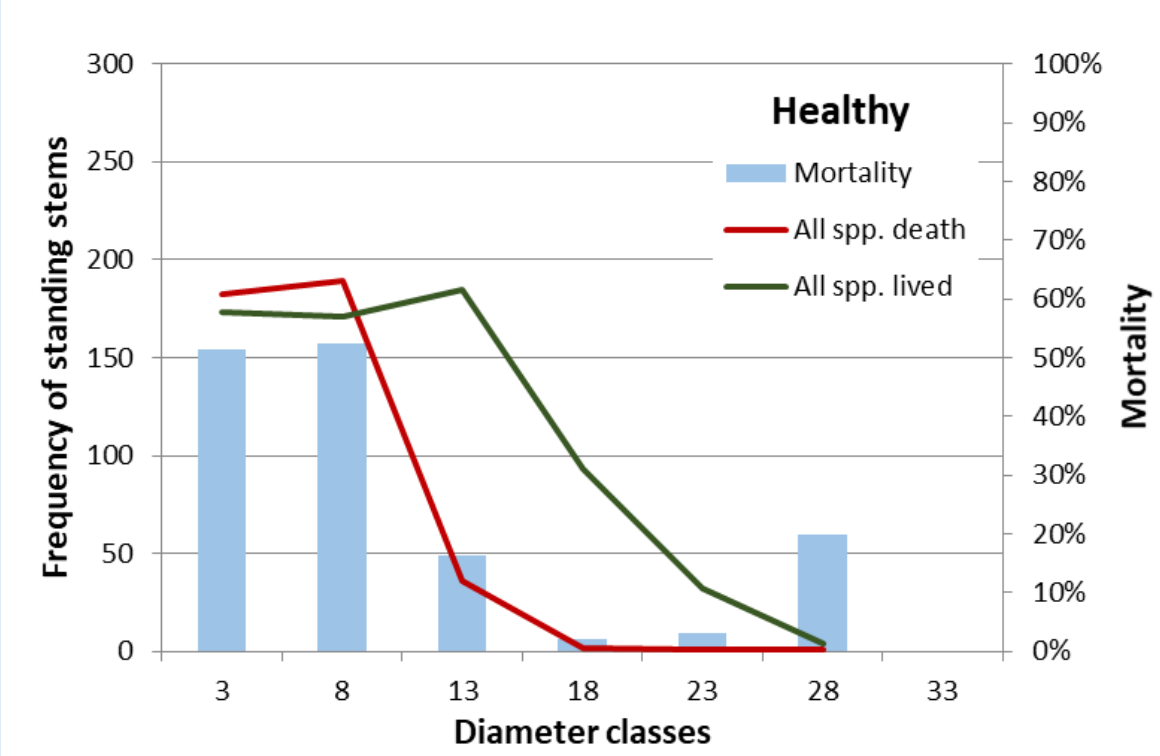
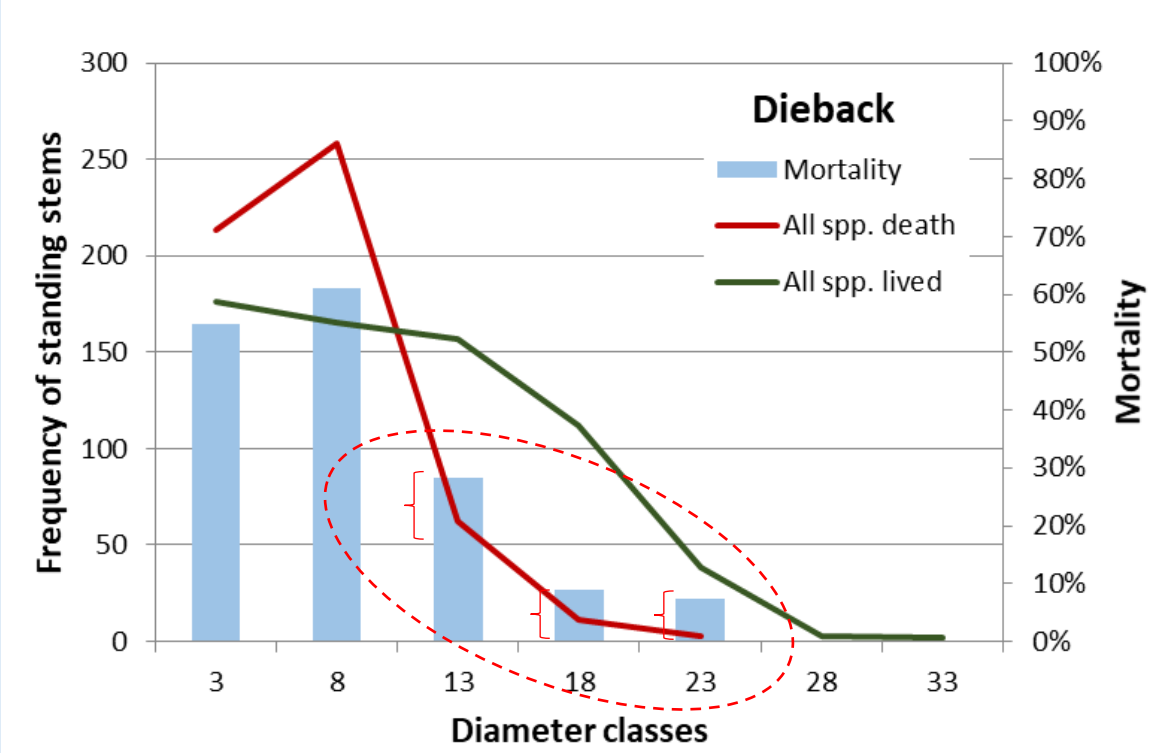
Tree species mortality - (based on plant diameters)

The stand is characterised by high frequencies of standing stems in the smaller diameter classes (all species: green and red lines)

The mortality is concentrated on the first two diameter classes, as typically occur during the development of even-aged forest stand, in both categories of plots.

In the middle and larger diameter classes, a slight increase of mortality is evident in the dieback plots.





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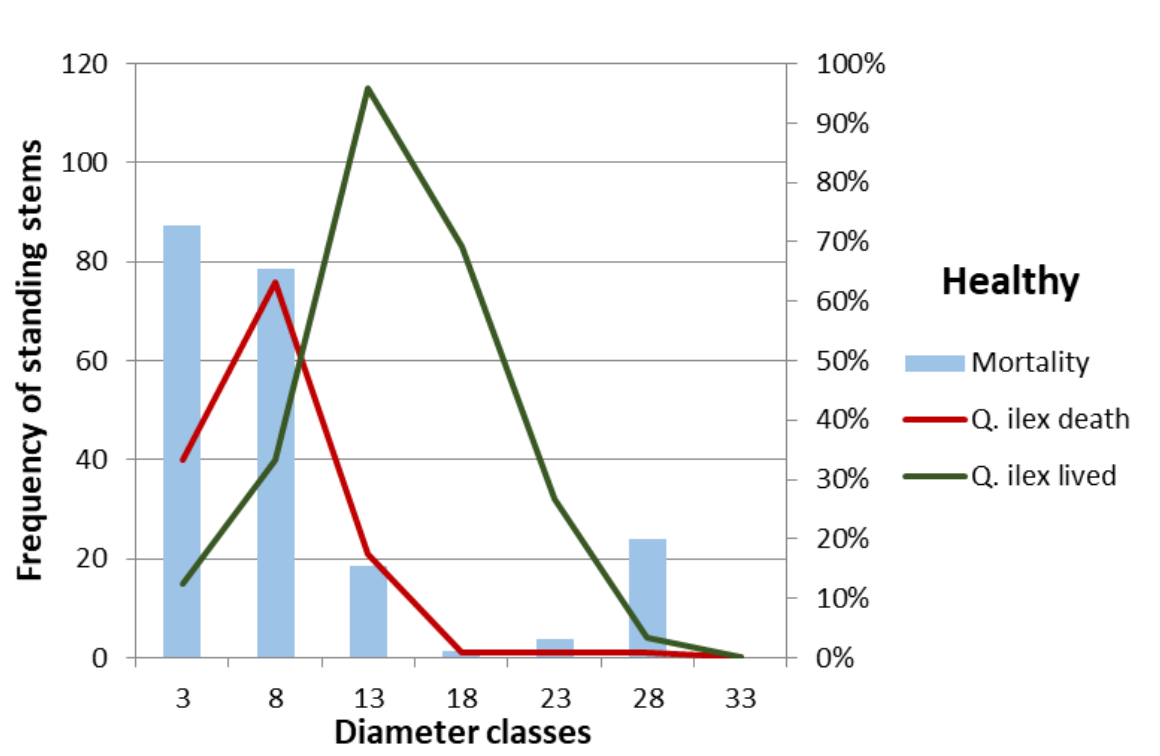
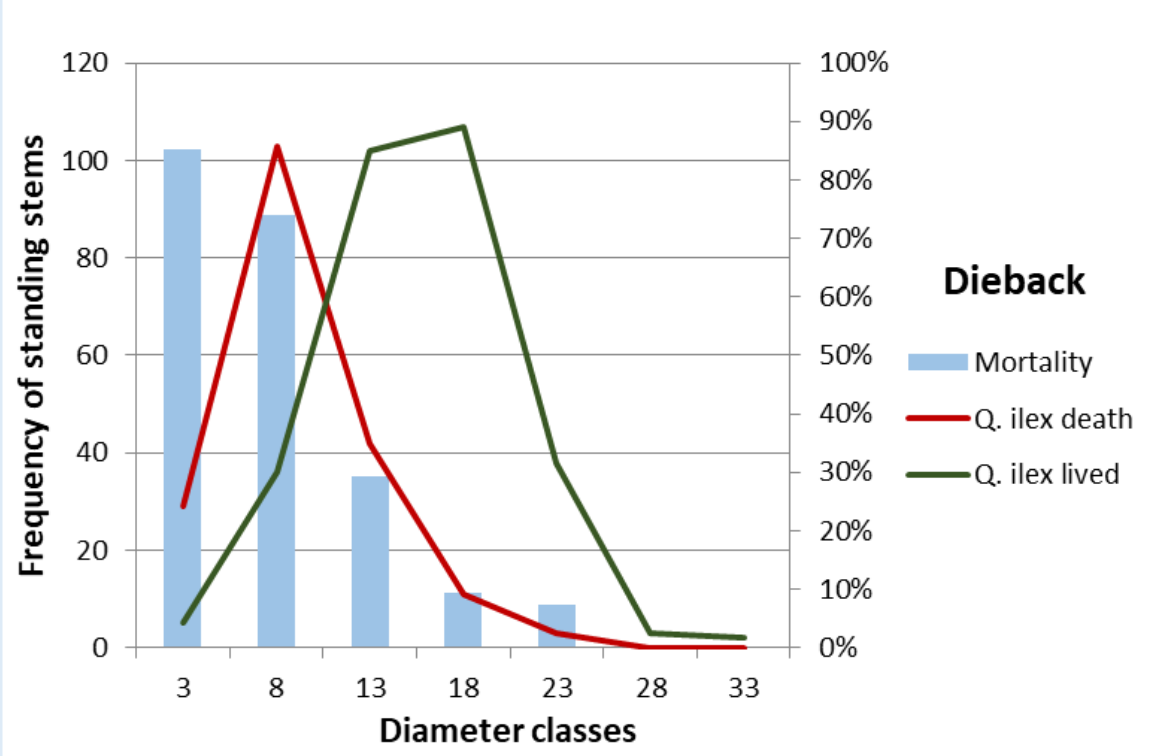
Q. ilex species mortality - (based on plant diameters)

Considering only the dominant species (*Q. ilex*), the competition processes modelled the structure of the forest stand suppressing the dominated shoots, producing a typical "normal" distribution around the average diameter (green line).





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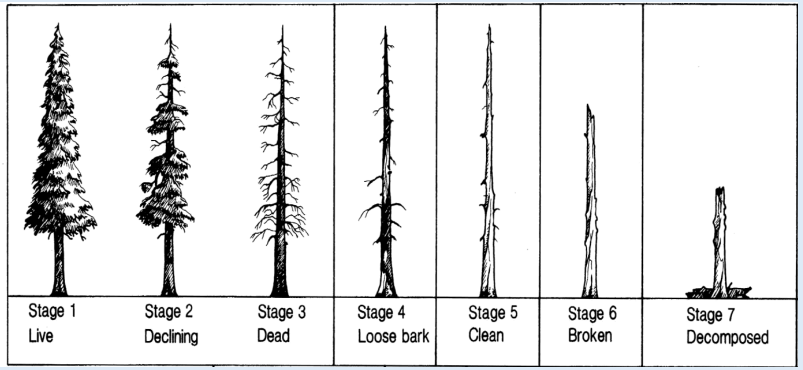

Q. Ilex **is mainly in the declining stage (relative recent process), while in** ***Fraxinus*** **the decline stage has a lower frequency and apparently is a recent phenomenon.**

Arbutus **is at the end of the process, while** ***Phyllirea*** **show two peaks.**

Declining trees are more frequents in the Dieback plots

The different stages of dieback are related with the time when the decline started.

Distribution in classes of vitality

	Q. ilex		Phyllirea		Fraxinus		Arbutus	
Classes	**Dieback**	**Healthy**	**Dieback**	**Healthy**	**Dieback**	**Healthy**	**Dieback**	**Healthy**
Live	8%	22%	14%	38%	**46%**	**61%**	2%	4%
Declining	**53%**	**45%**	**38%**	**25%**	31%	12%	3%	4%
Dead	13%	11%	5%	7%	2%	7%	10%	15%
Loose bark	10%	7%	7%	10%	9%	8%	18%	28%
Clean	2%	2%	4%	5%	2%	4%	21%	14%
Broken	6%	4%	9%	2%	4%	2%	11%	4%
Decomposed	9%	9%	**23%**	**13%**	5%	7%	**36%**	**32%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

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In summary

- **The forest of the north slope of *Monte Circeo* is an old coppice not more managed under natural transformation;**
- ***Arbutus* has been suppressed during the last decades, as consequence of the (light) competition with the upper canopy dominated by *Q.ilex;***
- **The natural competition among the shoots (stems) of the same stump (in *Q. ilex*), favourite the transformation of the forest structure;**
- **The decline of the *Phyllirea* (following the *Arbutus* suppression) seem to be a sign of the transformation to a pure *Q. ilex* forest, but possibly *Xylosandrus* could interrupt this transformation (biotic);**
- **A relative recent decline of *Q. ilex* causing the mortality of the whole stump (drought?), possibly open the space for the understory.**

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