Pheno-anomalies of sub-alpine *Vaccinium* heaths in response to climatic variations

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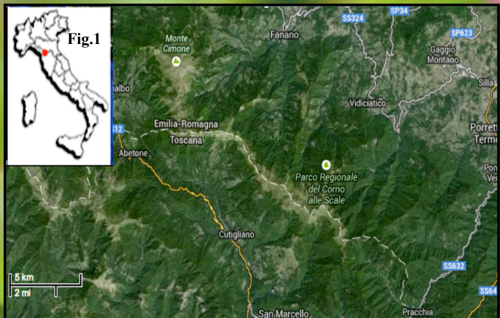
BACKGROUND

The N-Apennines summit flora and vegetation have high similarity with the Alps. Dwarf shrub-lands dominated by *Vaccinium* species occupy the undisturbed mountain ridges above the forest line. This vegetation forms a belt of little islands, exposed to a high risk of species extinction in a climate warming scenario (ABELI et al. 2012).



AIMS and METHODS

A phenological survey on *Vaccinium* heaths was repeated about thirty years after the first study, in the area of *Corno alle Scale* mount in the N-Apennines.
In line with the sampling method adopted in the earliest phases of the study (PUPPI & SPERANZA 1980)**, a phenological monitoring was undertaken in the same sites, located above the forest line, between 1600 and 1800 m asl** (PUPPI et al. 1994).
The phenology of each plant species of the selected plant communities was recorded in order to investigate the flowering patterns of the *Vaccinium* heaths and their variations.

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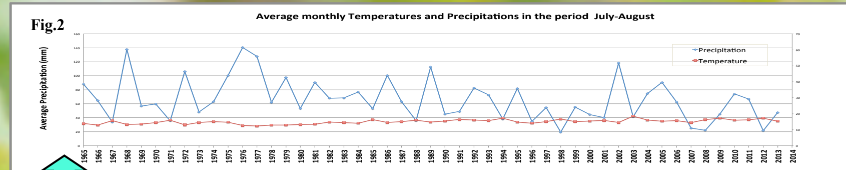
RESULTS

CLIMATIC VARIATIONS

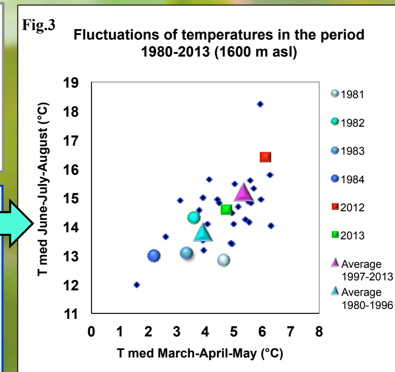
An increase in the annual mean temperature of the study area of about 0,4 °C per decade was observed (since 1961): the highest increases occurred in Spring and in Summer (MARLETTO et al. 2010). On the other hand, in the last decades there was a significant decline of precipitations in Winter and Summer. In addition, a rising trend of windiness was observed (BONAFEDE et al. 2014).

In summary, over the last decades, the study area has become warmer, less snowy, dryer and more windy.

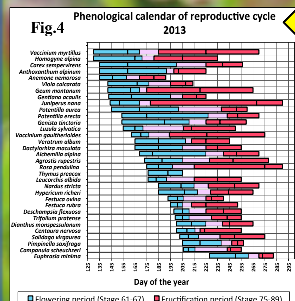


In Fig. 2, mean monthly Precipitation and Temperature of the hottest period of the year (July-August) in the study area, are plotted together in order to single out xero-thermal (XT) conditions (P/T<2) .
The frequency of Summer Dryness (XT) seems to rise after 1988.

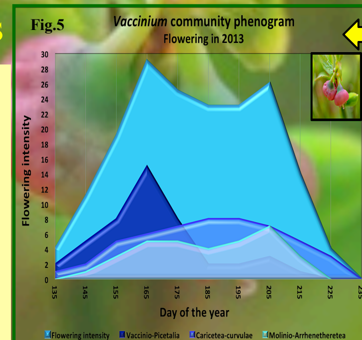
In Fig. 3, are shown Temperatures of Spring (March-April-May) and Summer (June-July-August) of the years 1980-2013, in the study area. **The Spring and Summer temperatures of the last 17 years were on average higher (+1,3 °C) than in the previous ones**.
Considering the years on study (1981-84 and 2012-13), 1984 was the coldest and 2012 the hottest; while, **2013 seems to be near to the average**.



AVERAGE PHENOLOGICAL CONDITIONS

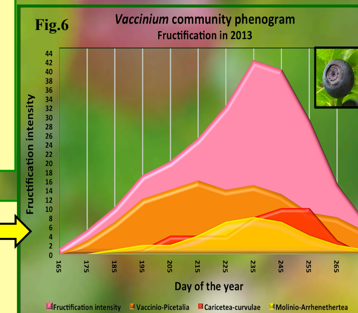


Under average conditions, as far as in 2013 (Fig.4), the flowerings begin at the end of May, after the melting of the last snow, and finish in September.
The mean Flowering day (Fd) in 1981 is 179 ± 23(SD), in 1982 Fd=180 ±21, in 1983 Fd=182 ±23 and in 2013 Fd=180 ±20



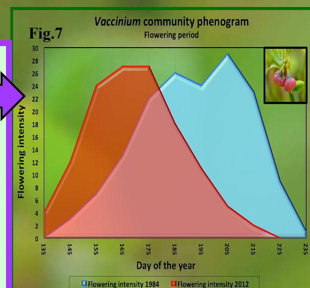
Under average conditions (i.e.1982 and 2013) **the blooming shows a bimodal pattern (Fig.5).**
The behaviour of ecological groups of species was examined The first peak (in mid June) is due mostly to the character species of sub-alpine heaths (*Vaccinio-Piceetalia*), while the second peak (end of July) is due mostly to mountain grasslands species (*Molinio-Arrhenatheretea*)

The fruiting shows an unimodal pattern (**Fig.6**).
The peak occurs at the end of August: in alpine grassland species (*Caricetea curvulae*) fructification occurs later than in other groups. All fruits ripe before September end.



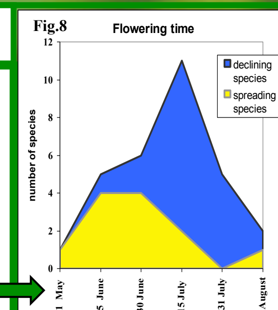
ANOMALIES IN FLOWERING

In the years 1984 and 2012, the flowerings diverged from the mean pattern (Fig. 7), showing a lower phenological diversity (in 1984 Fd= 194±19 (SD); in 2012 Fd=172 ±16).
The cold and snowy Spring of 1984 caused a marked delay of the blooming start and of the first peak (3-4 weeks). **In the year 2012, the hot and dry Summer caused the disappearance of the second flowering peak** and a dramatic advance of the blooming end.



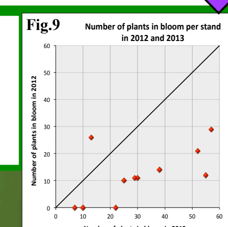
DECLINING SPECIES

The comparison of the actual vegetation with the historical data showed a **reduction of herb diversity and cover in time** (BONAFEDE et al. 2014).
It is noteworthy that many of the **declining species flower in July-August, a period under XT risk. (Fig.8)**



Owing to the Summer dryness, as observed in **2012,** these species suffered a significant **reduction** of the plants in bloom (**Fig.9**)

So, in the last decades, their seed production declined and, probably, their resilience too.



CONCLUSIONS

In the study area (1600-1800 m asl), temperatures increased during the last decades and dryness conditions occurred in several summers since 1994. Considering the years on study, 2013 seems to be near to the average climatic conditions and have a typical phenological behaviour, viceversa 1984 and 2012 show the strongest anomalies. Nevertheless, while the very cold spring 1984 led simply to an initial shift and to a compaction of the blooming, the xero-thermal stress of the summer 2012 caused a deep variation of the phenological pattern and a fail of reproduction in several late flowering plants. It is noteworthy that many grassland species, flowering in the driest period of the summer, actually show a declining trend.
In a climate-warming scenario, the low extension of these sub-alpine vegetation islands of the Apennines leads to a high extinction risk of the most sensible species. So, the monitoring of this vulnerable vegetation type seems necessary in order to detect the current trends and therefore should be continued in the future.