Translocation to prevent extinction in face of global change: the case of the sterile relict tree *Zelkova sicula*, Sicily, Italy

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Introduction

Zelkova sicula Di Pasquale, Garfì & Quézel is a narrow endemic tree listed in the Italian Red List of vascular plants and reported as 'CR' (Critically Endangered) according to IUCN criteria (Garfì *et al.*, 2017a). This species counts only two extant sub-populations located between 350 and 500 m a.s.l.. They colonize the bottom of little stream catchments of the outcropping base-rich volcanic rocks of the Hyblaean Plateau (SE Sicily), where they benefit from a seasonal water supply. Both sub-populations have been discovered recently (in 1991 and 2009, respectively) and are about 17 km distant from each other (Garfì *et al.*, 2011). There are approximately 260 and 1,540 individuals respectively, and both of them probably represent the result of century-lasting clonal spreading (root suckers) from two single triploid, non-reproductive, plants (Christe *et al.*, 2014). Hence, *Z. sicula* may be considered one of the rarest plants worldwide. Not capable anymore to

Flowering branchlet of *Zelkova sicula*
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spread out from its refugial sites, this species is threatened with increasingly frequent wildfires and extreme climatic events (Garfì *et al.*, 2017a). Consequently, translocation probably represents the most effective strategy to ensure its survival in face of the rising intensity of stress and disturbance linked to ongoing global change.

Goals

- Increase the number of self-sustained sub-populations of *Z. sicula*.
- Use both known genotypes to form each new sub-population.
- Better understand the ecological requirements of *Z. sicula* by following its response under new climatic conditions assumed to be more suitable than the current ones.
- Reduce the risk of extinction due to stress and disturbance factors linked with global change, e.g. extreme drought and wildfires.
- Set up the most effective criteria to ensure further translocation of the species in other areas of Sicily.

Success Indicators

- Number of plants successfully established after planting.
- Growth performance in terms of total height and main shoot length.
- Survival rate after 10 years.

Zelkova sicula two years after transplanting © G. Garfì

Project Summary

Feasibility: Due to the sexual sterility of *Z. sicula*, the design of a dedicated vegetative propagation protocol was needed. Since *Z. sicula* revealed extremely recalcitrant to either *in vivo* or *in vitro* techniques, this task required many trials over a number of years and though finally effective, in the end it allowed producing a rather low number of new plants (Carra *et al.*, 2019). Multi-year field observations highlighted the low fitness of the target species within its native habitat. Therefore, basic knowledge about its ecological requirements had to be improved. This issue took into account the data on growth performance recorded on a plant cultivated in

less constraining conditions (at 820 m a.s.l.), the study of the biogeographical and palaeobotanical literature concerning the niche width of the entire genus, several field surveys of many populations of the closest biogeographical relatives, namely *Z. abelicea*, on Crete (Greece), and *Z. carpinifolia*, in Azerbaijan and Georgia.

Watering after transplantation © G. Garfì

In addition, to ensure long-term conservation and sustainability, protected areas and public properties were preferred for the final site selection (Garfì *et al.*, 2017b). Concerning this point, sometimes complex administrative procedures for permission were needed; in some cases, where authorization was denied despite the assumptions of ecological suitability, we were forced to select alternative neighboring locations.

Implementation: After exploring 19 potential sites located in the mountainous ranges and protected areas of Sicily, four sites were selected for plantations, situated respectively on Nebrodi Mts. (Bosco Tassita, 1,309 m a.s.l.), Madonie Mts. (Bosco Pomieri, 1,340 m a.s.l.), Sicani Mts. (Bosco Ficuzza, 1,015 m a.s.l.) and Hyblean Plateau (Bosco Pisano, 507 m a.s.l.). All the planting areas are managed by the Sicilian Regional Forest Agency (DRSRT) and lie within mixed forest stands including deciduous broadleaved trees (*Quercus*, *Acer*, *Fagus*, *Castanea*) and subordinated *Taxus baccata* trees, with the exception of Bosco Pisano, where *Quercus suber* is the dominant species. The selected 3,000 - 5,000 m^2 large plots were fenced in order to protect the new plantations from browsing damages due to domestic and wild herbivores.

Zelkova plants were obtained from both *in vivo* and *in vitro* propagation techniques, using plant material collected from the two native sub-populations. Before their transfer in the wild, plantlets were acclimatized for one growing season in a forest nursery located under meso-Mediterranean climatic conditions. Planting was carried out in several stages. It started in June 2016, with 15 plants per site, respectively at Bosco Ficuzza and Bosco Tassita. It continued in the following winter with 11 additional plantlets in these two sites, and the translocation of 25 plants at Bosco Pomieri and Bosco Pisano, adding up 102 plants in 2016. A second planting step was done between September and December 2017, adding 19 plants in each of the four sites, thus raising to 178 the total of translocated plants. Planting was carried out in the understorey of existing forest communities, following locally uneven spatial patterns, and preferring half-shade conditions and streamside when possible.

Heavy snowfall damage at Bosco Ficuzza © G. Garfì

Special procedures were adopted to maximize the survival rate, like the use of hydrogel (a polyacrylate which absorbs a high amount of water and releases it slowly) in the planting hole, in addition to mulching with biodegradable mats to reduce plant evaporation. Watering was provided during the first summer after planting to prevent potential drought stress. A micro-weather station was set up in each site in order to collect environmental data useful to address future translocations, namely rainfall, temperature, air humidity and soil water content at three different depths (top soil, 30 and 60 cm).

Post-planting monitoring: Immediately after the first plantations and until present, a monitoring activity has been carried out at least once a month during the growth season (April to September). For each plantlet basic data were recorded at planting, such as population of origin, propagation technique (*in vivo* or *in vitro*), micro-environmental conditions (light regime, micro-topography, potential competition). Periodical data collection included survival rate, length of the main shoot, phenology, visible pathogens (herbivore insects, fungi) and physical damages (climatic stress, accidental breaks). The amount of plants that have survived up to now is extremely high: in total 169 plants (95%) are alive, five died in 2017 (two at Bosco Pisano, one at Bosco Ficuzza, two at Bosco Tassita) and four in 2018 (one at Bosco Pisano, two at Bosco Ficuzza, one at Bosco Pomieri). The mean yearly growth rate was satisfactory, ranging from 11.1 - 21.1 cm depending on the site and the year.

At the three most elevated sites some plants suffered from shoot breaks due to heavy snowfall during winter 2017 - 2018, and in spring 2019 also due to low temperatures. Significant insect defoliation was observed during two years on the plantations at Bosco Tassita and Bosco Ficuzza, whereas a number of plants in all sites showed low vigor, probably due to excessive shade from the pre-existing tree canopy. Therefore, it is planned to carry out thinning trials during the next winter.

Major difficulties faced

- The setup of effective *in vivo* or *in vitro* propagation techniques has been extremely time-demanding and still needs refinements to improve the success rate.

- The low number of available plants for translocation limited the possibility to test a wider range of ecological conditions in order to assess the most suitable ones.
- Underestimated insect damages and breakage due to heavy snow significantly reduced/prevented the potential yearly height growth.
- Unexpected cold stress may be invoked as the responsible for the low vigor of some plantlets at the most elevated sites.
- The administrative procedures needed to obtain the authorization to select and perform the plantations have often been time-consuming and hampered by excessive bureaucracy.

Major lessons learned

- Site selection must be done after obtaining the full support and agreement of all local stakeholders.
- Since the release in public areas is believed to be an essential prerequisite, the time span necessary for granting permission should be adequately evaluated in the translocation planning process.
- Based on a cross-control of the growth rates and the few casualties that have occurred up to the present day, some of the selected sites seem to be too cold (at least during winter season). Hence, a longer time-series of local climatic data is needed to identify the real climatic niche of the target species in order to find out the most suitable sites where further nuclei could be released.
- The shade regime should be the object of accurate evaluation through time and the eventuality of specific silvicultural interventions (e.g. thinning the canopy of pre-existing tree cover) should be included in a post-planting conservation planning.
- Up to present the plants issued from *in vitro* propagation seem to respond better in terms of overall growth rate and vigor. This aspect needs to be better understood, hence monitoring must be continued for at least the next five years.

Success of project

Highly Successful	Successful	Partially Successful	Failure

Reason(s) for success/failure:

- Most of the plants responded very well to translocation, and the planting procedures as well as the post-planting watering have played an important role in ensuring their establishment at the very early stage.
- The planting and the very good establishment rate of the plants originating from both native subpopulations will ensure the survival and the effective conservation of the whole genetic diversity of the species.
- The effective cooperation of the staff (from field workers to officials) of the

Sicilian Regional Forest Agency that was involved in all the concrete planting steps was crucial for the successful results.

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