

Guidelines and recommendations for the long-term conservation of *Zelkova abelicea* in Crete

PREPARED BY: Dany Ghosn, Ilektra Remoundou, Laurence Fazan, Panagiota Gotsiou, Adamantia Kokkinaki, Eleni Markaki, Salvatore Pasta, Giuseppe Garfi, Costas Thanos and Gregor Kozlowski



Author affiliations

Dany Ghosn and Ilektra Remoundou

Department of Geoinformation in Environmental Management – CIHEAM Mediterranean Agronomic Institute of Chania, Alsyllo Agrokepiou, 73100 Chania, Greece, dghosn@maich.gr, hlektra@maich.gr

Laurence Fazan

Department of Biology and Botanical Garden, University of Fribourg, Chemin du Musée 10, 1700 Fribourg, Switzerland, laurence.fazan@unifr.ch

Panagiota Gotsiou, Adamantia Kokkinaki and Eleni Markaki

Mediterranean Plant Conservation Unit – CIHEAM Mediterranean Agronomic Institute of Chania, Alsyllo Agrokepiou, 73100 Chania, Greece, yiota@maich.gr, adamantia@maich.gr, elemar@maich.gr

Salvatore Pasta and Giuseppe Garfi

Institute of Biosciences and BioResources (IBBR) – Italian National Research Council (CNR), Corso Calatafimi 414, 90129 Palermo, Italy, salvatore.pasta@ibbr.cnr.it, giuseppe.garfi@ibbr.cnr.it

Costas Thanos

Department of Botany, National and Kapodistrian University of Athens, Panepistimiopolis, 15784 Athens, Greece, cthanos@biol.uoa.gr

Gregor Kozlowski

Department of Biology and Botanical Garden, University of Fribourg, Chemin du Musée 10, 1700 Fribourg, Switzerland, Natural History Museum Fribourg, Chemin du Musée 6, 1700 Fribourg, Switzerland, Eastern China Conservation Centre for Wild Endangered Plant Resources, Shanghai Chenshan Botanical Garden, 3888 Chenhua Road, Songjiang, 201602 Shanghai, China, gregor.kozlowski@unifr.ch

Keywords

Conservation actions, *Zelkova abelicea*, Endemic species, Cretan mountains, Overgrazing, Consultation, Decision-makers

Photo credit

Front cover, back cover, 21: Laurence Fazan

1, 2, 3, 5, 7, 8, 9, 10, 11, 13, 16, 17, 18, 20 Ilektra Remoundou

4 Eleni Markaki

6, 15 Dany Ghosn

12 Gregor Kozlowski

14 Panagiota Gotsiou

19 Salvatore Pasta

© - 2022 - Conservation of *Zelkova abelicea* in Crete (2014 - 2021)

Published by CIHEAM IAMC - Mediterranean Agronomic Institute of Chania

T: 28210 35000, E: info@maich.gr, W: www.iamc.ciheam.org

Contents

1. Introduction	1
2. Conservation guidelines and recommendation measures	2
2.1 On the <i>in-situ</i> level	2
2.2 On the <i>ex-situ</i> level	3
2.3 On the communication and outreach level	4
2.4 On the legal level	4
2.5 On the research level	5
3. Overview of field findings and lessons learnt	6
3.1 <i>In-situ</i> conservation actions	6
3.1.1 Tree growth	6
3.1.2 Seedlings' survival	8
3.1.3 Epiphytic lichen and bryophyte diversity	8
3.2 <i>Ex-situ</i> conservation actions	9
3.3 Communication and outreach activities	11
4. Project background.....	12
5. The species – facts and information about <i>Z. abelicea</i>	14
6. Last but not least	17
7. References	18
8. Annex	20
Appeal for the enhancement of conservation measures of <i>Z. abelicea</i>	20



Z. abelicea tree form Lefka Ori, Omalos (1)

1. Introduction

Within the framework of the International Zelkova project (www.zelkova.ch), in partnership with the University of Fribourg – Switzerland and with funds from the Fondation Franklinia (<https://fondationfranklinia.org/>), the CIHEAM-MAICh in collaboration with the four Forest Directorates of Crete initiated in 2014 the first phase (2014-2016), in 2017 the second phase (2017-2018) and in 2019 the third phase (2019-2021) of a project entitled: “Conservation of *Zelkova abelicea* in Crete” (<https://abelitsia.gr/en/>).

The general objective of the project was to enable, enhance and promote the long-term conservation of the endangered Cretan tree *Z. abelicea* by coupling *in-situ* and *ex-situ* conservation actions with communication and outreach activities, while at the same time gathering valuable scientific information about the ecology, the biology and the risk level of the species. This project represents the first attempt between local and international stakeholders to develop a common approach and methodology for the conservation of *Z. abelicea* in Crete, whose high rate of endemism depends on both environmental and anthropogenic factors.

This document presents a series of guidelines and recommendations based on the results of 8 years of field research and monitoring activities (cfr. section 3) aiming at improving the knowledge about *Z. abelicea* in Crete in order to find out the most effective way to protect it. The main results of the project were presented during a dedicated session of the 3rd Mediterranean Plant Conservation Week (www.medplantsweek.uicnmed.org/public_html/medplantsweek/en/3rd-mpcw/about-3rd-mpcv/), 27 September - 1 October 2021, held at the CIHEAM-MAICh, and co-organised by CIHEAM-MAICh and other international organisations such as the International Union for the Conservation of Nature (IUCN), bringing together many actors involved in plant conservation (i.e. representatives from universities, research institutions, gene banks, botanical gardens, parks, management bodies of protected areas, NGOs, etc.).

The suggested guidelines and recommendation measures can be used as support for the long-term conservation of the species and are addressed to National Authorities, decision makers, nature conservationists or anyone interested in the conservation of *Z. abelicea*.

Following an intentional bottom-up structure, we present at first the guidelines and recommendation measures, then the results and outcomes of the *Z. abelicea* conservation project, the project aims and actions and we conclude by reporting general facts about *Z. abelicea* followed by a conclusive part.

Habitat of *Z. abelicea* Lefka Ori, Omalos (2)



2. Conservation guidelines and recommendation measures

2.1 On the *in-situ* level

FOCUS ON FENCING small-scaled (20-100 m²) plots which are sufficient to allow re-growth of *Z. abelicea*. Small-scaled fences are less costly and strongly reduce the risk of intentional destruction compared to larger fenced areas,

ACTIVELY INVOLVE LOCAL STAKEHOLDERS (mostly shepherds) in the selection of fenced plots,

TWO TO FIVE YEARS OF FENCING is sufficient to allow some individuals to grow high enough to escape browsing from goats, but this depends on initial tree height and growth rates,

CONSIDER INITIAL *Z. abelicea* INDIVIDUAL HEIGHT depending on the duration of the project, smaller individuals will take more time to grow than taller ones,

ADDRESS THE SOCIO-ECONOMIC NEEDS OF LOCAL COMMUNITIES living in the vicinity of *Z. abelicea* populations: realistic and adequate (eco-friendly) alternatives, like livelihood activities other than uncontrolled husbandry targeting revenue generation mechanisms for local communities should be identified and carried out. While such alternative activities may appear to be dissociated from conservation, they actually represent the most important factor to sustainably address the socio-economic needs of the local communities and/or to reduce the overgrazing and over-browsing pressures on the species hence enabling and enhancing its natural regeneration and ensure its long-term conservation,

IDENTIFY FURTHER SEVERAL STRATEGICALLY IMPORTANT STANDS of *Z. abelicea* which should be fenced for a time lapse long enough to allow many plants to grow sufficiently to escape to the browsing and trampling impacts,

CREATE A NETWORK OF PLANT MICRORESERVES (PMRs) to protect the species in small land plots that are of peak value in terms of plant richness, endemism or rarity



Z. abelicea tree form Lefka Ori, Imbros (3)

(for examples see: http://www.plantnet.org.cy/plant_micro-reserves.html, <http://cretaplant.biol.uoa.gr/en/pmr.html>). If initiated, actions for the establishment of PMRs should be implemented in cooperation with the Decentralized Administration of Crete, the local Forest Directorates, local Municipalities and local land users and stakeholders,

PRIORITY SHOULD BE GIVEN to the *Z. abelicea* populations of central (Kedros and Psiloritis) and eastern (Dikti and Thripti) Crete since they already suffer from climatic stress and show a slower vegetative response and are currently mostly unable to reproduce by seed. Western populations (Lefka Ori) should not be excluded a priori,

PROMOTE AND ENCOURAGE the use of *Z. abelicea* in future forest plantations carried out by both public bodies (e.g., Forest Directorates) or private owners, especially on sites that could be preliminarily considered not affected by the current conservation issues (e.g. overgrazing, misuse of wood resources, etc.) affecting the existing populations,



Z. abelicea fruit collection
Lefka Ori, Omalos (4)

MAINTAIN AND REPAIR (when needed) currently fenced plots throughout the distribution range of the species (31 in total) including the Omalos plantation. The uninterrupted fencing of previously browsed *Z. abelicea* individuals is crucial, as only when individuals are continuously fenced over several years will they be able to reach an adequate height to escape browsing and start producing fruit,

REPLACE (when needed) currently installed mini-fences enclosing newly established seedlings in the wild (Lefka Ori - Xeropotamos and Machi).

2.2 On the *ex-situ* level

INVEST ENOUGH RESOURCES, TIME AND MANPOWER to collect, curate and store seeds from populations where little or no seeds have been collected (Southern side of the Lefka Ori) and from populations with low sound seed proportions (Central and Eastern Crete populations),

DEDICATE PART OF THE SEED COLLECTION to produce plant materials to guarantee - when needed - the availability of plants for use in recovery plans,

CONTINUE AFTERCARE (PRUNING, WEEDING) of *Z. abelicea* seedlings in the Omalos plantation that provides a recreation and education outdoor space for local schools and a wider spectrum of local and foreign visitors. This plantation should be managed by local stakeholders (Municipality of Platania and/or the Forest Directorate of Chania) and will provide, on the long term, “certified” alternative source for making traditional “katsounes” (shepherds walking sticks).

2.3 On the communication and outreach level

INVOLVE ALL KEY STAKEHOLDERS in the decision-making process,

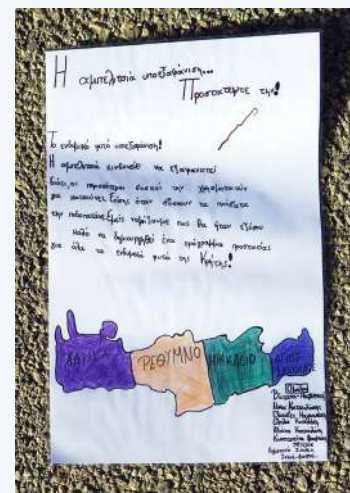
USE STRATEGIC COMMUNICATION channels, material and activities to support effective public participation and improve public awareness in relation to the species and its habitat,

MAINTAIN AND REGULARLY UPDATE the project website (hosted at the main server of the CIHEAM-MAICh) for at least 5 years after the end of the project,

MAINTAIN AND REPAIR (when needed - local Forest Directorates) information signs installed at the main squares of villages located near *Z. abelicea* natural stands,

ORGANIZE ENVIRONMENTAL EDUCATION AND INFORMATION CAMPAIGNS related to *Z. abelicea* at the exhibition center of the CIHEAM-MAICh in the form of student-days once per year,

CONTINUE WITH MEDIA PUBLICITY and dissemination of communication materials at the local and regional levels.



Student drawings
Communication and
outreach activities (5)

2.4 On the legal level

ADOPT ADDITIONAL MEASURES to reduce the impact of overgrazing on the flora of the Cretan mountains,

INVOLVE LOCAL STAKEHOLDERS (mostly shepherds) to find a more sustainable and shared way of managing grazing activities and regulating grazing pressure,

IMPROVE THE LEGAL PROTECTION STATUS of the species, for example as “traditional umbrella species”, i.e. a species whose conservation improves the conservation not only of other co-occurring species but also at the ecosystem and landscape level,

Communication and outreach activities (6)



FOLLOW UP ON the “Appeal for the enhancement of conservation measures of *Zelkova abelicea*” that has been sent to the National Authorities and decision makers to adopt further measures to reduce the impact of overgrazing on the vascular flora of the Cretan mountains (see Annex).

2.5 On the research level

DEVELOP AN EFFECTIVE PROTOCOL for the vegetative propagation of plant material from shoot or root cuttings, as well as through micropropagation techniques, mainly for populations which show low to null seed soundness (i.e. the central and eastern populations),

EXPERIMENT WATERING or developing humidity capturing devices to monitor mature individuals in the sites where *Z. abelicea* show to suffer more drought stress (Psiloritis, Dikti and Thripti populations) in order to see if these tools can increase the proportion of sound fruits (see e.g. Carrera-Villacrés et al. 2017, 2020, Dodson & Bargash 2015, Pinche & Ruiz 1996 and <https://www.youtube.com/watch?v=0F7C-QMd6mQ4>),

MINI-FENCES (30 x 30 x 30 cm) are an efficient and cheap way to protect newly established seedlings in the wild,

FENCE MORE DWARFED INDIVIDUALS OF THE MORE DROUGHT-STRESSED POPULATIONS to experiment and monitor if their growth rate can be increased,

CONTINUE EXPLORING the biodiversity associated with *Z. abelicea*,

MONITOR AND UPDATE the conservation status of the species.

The adoption and the implementation of these guidelines and recommendations measures by local and national authorities responsible for the management of natural areas and for the protection of threatened plant species will further enhance and promote the long-term conservation of the *Z. abelicea* in Crete.



3. Overview of field findings and lessons learnt

Below we briefly present the main findings about the growth, the regeneration and the biodiversity patterns dealing with *Z. abelicea* trees, as well as the implementation of *in-situ* and *ex-situ* conservation actions and outreach activities that were carried out during the *Z. abelicea* conservation project between 2014 and 2021.

3.1 *In-situ* conservation actions

3.1.1 Tree growth

Fazan et al. 2017, 2021, 2022 and 2022a - *Z. abelicea* technical reports (2019, 2020 and 2021)

FENCING SMALL PLOTS (20 – 100 m²) is efficient in allowing the protection and growth of *Z. abelicea* individuals,



Small fence
Lefka Ori, Omalos (8)

SMALL-SCALED FENCING PROVED to have a lower risk of being intentionally destroyed compared to larger fenced areas,

WHEN PROTECTED FROM BROWSING, *Z. abelicea* individuals produce on average shoots that are twice as long than those of individuals in unprotected areas,

GROWTH IS MAXIMAL during the first and second years after browsing removal, after which it slowly decreases but stays higher than in unprotected areas,

WITHIN THE FENCED PLOTS, the number of individuals tall enough to escape browsing doubled in just four years after browsing removal,

WHEN PROTECTED FROM BROWSING, taller individuals grow faster than shorter individuals,

SPATIAL DIFFERENCES IN GROWTH RATES of *Z. abelicea* individuals exist between Cretan mountain ranges,

***Z. abelicea* INDIVIDUALS IN THE LEFKA ORI AND MT. KEDROS** grow on average two times as much as trees from Dikti and Thripti,

GEOGRAPHICAL POSITION ON THE ISLAND, PRECIPITATION IN JUNE AND INITIAL TREE HEIGHT are significant in explaining spatial differences in *Z. abelicea* growth, while soil characteristics, altitude, slope or heatload apparently played no role,

SPRING AND EARLY SUMMER CLIMATIC CONDITIONS play an important role in determining *Z. abelicea* growth and highlight differences throughout the island,

***Z. abelicea* INDIVIDUALS IN EASTERN CRETE** are smaller than trees in central and western mountain ranges,

***Z. abelicea* INDIVIDUALS FROM MT. DIKTI AND THRIPTI** suffer more from water limiting climatic conditions than trees from the Lefka Ori and Mt. Kedros,

DIFFERENCES IN SOIL NUTRIENT CONTENT was found between fenced plots situated on slopes versus those situated on flat doline floors, but none of the investigated soil variables were important in determining *Z. abelicea* growth patterns.

Z. abelicea shoot growth after browsing removal (9)



3.1.2 Seedlings' survival

Fazan et al. 2021

NATURALLY ESTABLISHED SEEDLINGS were found only in the Lefka Ori mountain massif and nowhere else,

THE INSTALLATION OF MINI-FENCES over individual seedlings, naturally established in the wild, is efficient to protect them from being browsed,

SEEDLING SURVIVAL IN THE WILD was very rare, even in fenced areas, suggesting that the impact of summer drought could be of more importance than browsing pressure.



Seedlings of *Z. abelicea* naturally established in the wild Lefka Ori, Omalos (10)



Mini-fences protecting seedlings of *Z. abelicea* Lefka Ori, Omalos (11)

3.1.3 Epiphytic lichen and bryophyte diversity

Fazan et al. 2022b

***Z. abelicea* INDIVIDUALS** host a high number of epiphytes, 60 species of lichens and 10 bryophytes were recorded,

THE LEFKA ORI MOUNTAIN RANGE in western Crete seems to be a hotspot for epiphytic lichens on *Z. abelicea*,

BRYOPHYTES HAD THE HIGHEST DIVERSITY on Mt. Kedros in central Crete,

MT. PSILORITIS REVEALED to be the poorest area in terms of epiphytic diversity and included only lichens that are tolerant to high levels of disturbance, eutrophication and aridity,

BRYOPHYTES WERE ABSENT from trees sampled in Psiloritis, Omalos Viannou (Dikti Mts.) and Thripti Mts,

GEOGRAPHICAL POSITION AND TREE TYPE (dwarfed or normal growing) were important factors influencing the epiphytic community encountered on *Z. abelicea*,

DWARFED *Z. abelicea* individuals were found to have as much epiphytic diversity as normal growing individuals,



Xanthoria parietina and *Pleurosticta acetabulum* lichens on *Z. abelicea* Lefka Ori, Omalos (12)

STRONG INFLUENCE OF local pastoral activities was found on the epiphytic lichen and moss communities with a predominance of eutrophication-tolerant and disturbance-tolerant species,

EUTROPHICATION-SENSITIVE AND DISTURBANCE-SENSITIVE species were found in several sites along with more tolerant species despite the strong influence of pastoral activities and disturbance,

3.2 Ex-situ conservation actions

Fournaraki & Thanos, 2006 - Fazan et al. 2022a - *Z. abelicea* technical reports (2019, 2020 and 2021)



Source: Fournaraki C., Thanos C.A. (2006). *Zelkova abelicea*, the unique endemic tree of Crete and its conservation. ENSCONEWS 1: 14-16)

ONLY TREES THAT HAVE GROWN ENOUGH TO ESCAPE BROWSING might produce fruit,

GERMINATION EXPERIMENTS ON THE SEEDS OF *Z. abelicea* showed that low temperatures (10 °C) are needed for seeds to germinate,

SEEDLINGS WERE SUCCESSFULLY grown from *Z. abelicea* populations that had sound fruit (mainly western Lefka Ori populations) and are available in the nurseries of the local Forest Directorates,

FRUIT PRODUCTION follows a masting behavior (most fruiting trees produce fruit synchronously every 2-3 years, with low to null fruit production in the years in between),

PROPORTION OF FRUITS WITH SOUND SEEDS are highly fluctuant, ranging from 0% to 56% depending on the sampled tree, locality and year of collection,

Z. abelicea TREES IN THE LEFKA ORI have a higher proportion of sound fruit than trees from central and eastern Crete,

96% OF Z. abelicea trees investigated from the Lefka Ori had sound fruit,

NONE OF THE INVESTIGATED Z. abelicea TREES FROM MT. PSILORITIS had sound fruits and only 20% of those from Dikti,

DURING THE LAST THREE CONSECUTIVE YEARS OF THIS PROJECT (2018, 2019 and 2020), the rate of sound fruit from *Z. abelicea* populations in Psiloritis, Kedros and Dikti mountains, were found to be extremely low or null,

FRUIT COLLECTION AND SEEDLING PRODUCTION was hampered from central and eastern Crete populations due to their very low to null proportion of sound seeds,

ALTERNATIVE WAYS OF OBTAINING PLANTS for propagation actions were investigated (especially from populations with no sound fruits), but vegetative propagation of shoot and root suckers revealed to have very low to null success,

A YET UNKNOWN GALL MIDGE belonging to Cecidomyiidae (Diptera) was found to form galls on *Z. abelicea* flowers and has been detected from several sites throughout the distribution range of the species,

TREES WITH HIGH QUANTITIES OF GALLS produce less fruits, but fruit soundness is not impacted or influenced by gall presence or absence,

SECURING THE PRESERVATION OF THE GENETIC VARIABILITY OF THE SPECIES cannot rely only on the availability of plant material derived from fruits.



Plantation of *Z. abelicea*
Lefka Ori, Omalos (13)



Planting event
Omalos plantation, Lefka Ori (14)

3.3 Communication and outreach activities

CONSENSUS AND ACTIVE INVOLVEMENT OF LOCAL STAKEHOLDERS AND AUTHORITIES is a pre-requisite for successful conservation actions,

CONFLICTS WITH LAND USERS (mainly shepherds) exist and can strongly hamper any conservation effort (due to the lack of a regional official cadaster regulating land property and use in Crete). This particular issue turned to be one of the most important challenges to perform an effective in situ conservation of *Z. abelicea* and its plant community,

THE SUCCESS OF ANY CONSERVATION EFFORT depends to a large extent on information and environmental education activities, especially those targeted to the local communities (mainly shepherds), as they are more inclined to accept restrictions when they know the reasons for the rules. This has been reflected by the cessation of acts of vandalisms on fenced plots observed during the 1st phase of the project and the increase demand for planting *Z. abelicea* seedlings in public green spaces. This is crucial not only for immediate conservation goals but also to ensure the long-term success of any conservation effort,

ADDRESSING SOCIO-ECONOMIC NEEDS of mountain local communities living in the vicinity of *Z. abelicea* populations is imperative to the long-term success of the *in-situ* conservation of the species in particular, its associated plant communities and the forest habitat where it grows, in general,

LOCAL COMMUNITIES STARTED to recognize that only through nature conservation, nature-based tourism can provide alternative sources of income.

These field findings and lessons learnt have important implications on future conservation actions of *Z. abelicea*, as they can help choose which stands and which individuals to protect in priority. Moreover, these findings are alarming for the long-term conservation of the species, at least outside of the Lefka Ori mountain range in western Crete and mainly in the eastern part (Dikti and Thripti) of its natural distribution range.



Local information event
Kavousi, Lasithi (15)

4. Project background

Since the beginning of the project, *Z. abelicea* individuals within selected fenced plots have been protected from grazing and browsing. The annual growth of the species as well as vegetation changes within fenced plots have been monitored. Fruit collection, curation and storage have been taking place; plant material derived from fruits and/or cuttings has been produced and transplanted in *ex-situ* plantations and/or in public green spaces. Lack of public awareness has been diminished at all implementation sites and cooperation between local institutions, local authorities and local inhabitants has been endorsed and improved engaging all relevant stakeholders in the process of conserving and protecting the species.

One of the main objectives of the 3rd phase (2019-2021) of the project was to consolidate and capitalize on the results achieved during its 1st and 2nd phases to ensure their long-term effectiveness and sustainability and to define guidelines and recommendations for the long-term conservation of the species in Crete. In its 3rd phase, the project carried on all the conservation and communication and outreach activities initiated in 2014, quantified the effect of excluding grazing and browsing on the growth of the species and on local vegetation dynamics, defined the relationship between abiotic and/or biotic factors and the growth rate of the species on different mountain ranges of Crete, engaged all relevant stakeholders in the process of conserving and protecting the species and capitalized on the positive results already achieved in its 1st and 2nd phase.



Monitoring the growth of *Z. abelicea* (16)

In-situ activities included:

- ➔ Fencing small plots within most natural populations of Crete,
- ➔ Monitoring the growth of *Z. abelicea* as well as vegetation changes within fenced plots,

- ➔ Investigating the effects of abiotic and biotic factors on the growth of the species,
- ➔ Studying dispersal shoot characteristics,
- ➔ Assessing fruit soundness of mature *Z. abelicea* trees,
- ➔ Investigating insect galls found on *Z. abelicea* flowers and their impact on fruit production,
- ➔ Investigating lichen and bryophyte diversity growing on *Z. abelicea* individuals,
- ➔ Investigating the microarthropod community occurring on *Z. abelicea*.

Ex-situ activities included:

- ➔ Fruit collection, curation and storage,
- ➔ Propagation and cultivation of seedlings and cuttings,
- ➔ *Ex-situ* plantation

Communication and outreach activities included:

- ➔ Development of a local project website,
- ➔ Implementation of information and environmental education events to promote and advertise the values of *Z. abelicea* to the public and influence decision-makers,
- ➔ Dissemination of communication material and project results

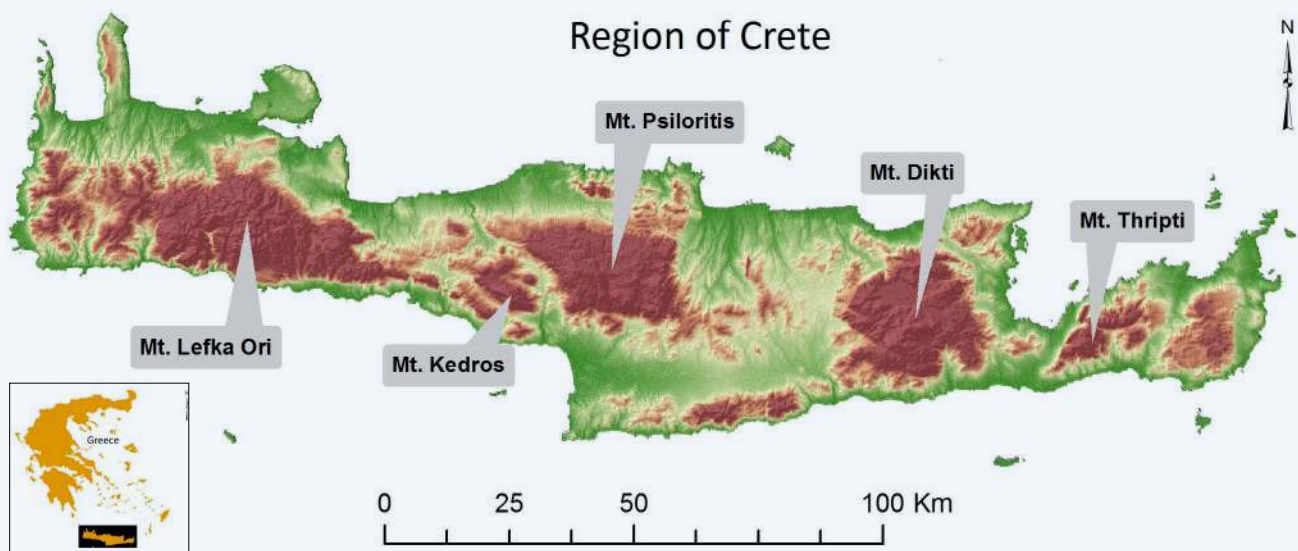
Fruit collection of
Z. abelicea (17)



5. The species – facts and information about *Z. abelicea*

Zelkova abelicea Lam. (Boiss.) (Ulmaceae) is of outmost scientific and conservation interest. It is a Paleogene relict, deciduous tree species, endemic to the island of Crete. It holds a very strong patrimonial value, as traditional shepherd walking sticks (katsounes) are preferentially made with its hard, light, durable and bendable wood.

The distribution of *Z. abelicea* is fragmented and is confined to six spatially and genetically distinct populations.



Distribution of *Z. abelicea* natural populations

It is found in open, mountain forest communities, usually mixed with maple (*Acer sempervirens*), kermes oak (*Quercus coccifera*) and occasionally Mediterranean cypress (*Cupressus sempervirens*) trees.

Z. abelicea trees grow between 800 and 1800 m a.s.l. in all mountain massifs of Crete; in the Lefka Ori, Kedros, Psiloritis, Dikti and Thripti around karstic sinkholes, rocky slopes, along gullies or temporary rivers most often on north-facing slopes (Bauer and Bergmeier 2011, Egli 1997, Fazan *et al.*, 2012, Goedecke and Bergmeier, 2018, Sarlis, 1987, Søndergaard and Egli, 2006). The majority of the populations occur in the Lefka Ori and Dikti mountain massifs. Under favorable conditions, the species can reach a height of 15-20 m.

Largest trees are often found growing next to abandoned shepherd huts. In the past,



Habitat of *Z. abelicea* - Dikti, Protolitsa (18)

trees were pollarded and the leaves used as summer forage for the flocks (Bauer and Bergmeier, 2011, Rackham and Moody, 1996).

The majority of individuals across the island exhibit stunted, dwarfed, shrub-like form due to overbrowsing by goats, with multiple stems and very slow growth (Fazan et al. 2012, Kozłowski et al. 2012).

Dwarfed overbrowsed individuals do not produce fruit and can be several hundred years old, indicating more or less continuous and long-lasting herbivore pressure (Sarlis 1987, Fazan et al. 2012).

The species propagates easily by vegetative root suckers, especially when erosion or disturbance occurs (Egli, 1997, Fazan w., 2012, Kozłowski et al., 2014, 2018, Søndergaard and Egli, 2006).

Massive seed production occurs every two to three years (masting behavior) (Egli, 1997; Fournaraki & Thanos, 2006; Søndergaard & Egli, 2006, Fazan et al. 2022a). Previous studies pointed out that seeds germinate very slowly and need cold stratification for several months and are therefore very sensitive to climate fluctuations as well as climate change (Fournaraki and Thanos, 2002).

All populations are significantly threatened by intensive pastoralism. The most important pressure is overgrazing and browsing through livestock mainly by goats and sheep with a major negative impact on tree habit, vigour and natural regeneration.

Soil erosion is the second most important disturbance - clearly correlated with intensive trampling and grazing. Climate change, water stress, fire as well as lack of public awareness represent additional threat factors. Moreover, the illegal pruning

Z. abelicea dwarfed, shrub-like form vs tree form
Lefka Ori, Omalos (19)





Z. abelicea - vegetative root suckers (20)

of trees to produce traditional walking sticks (katsouna) hinders the growth and development of fruiting trees (Bauer and Bergmeier, 2011, Egli, 1997, Kozłowski et al., 2012, Sarlis, 1987). Despite its threatened status and its relative rarity, *Z. abelicea* is an essential component of the Cretan mountains. Not only does it provide a unique ecosystem within its branches, bark and roots for numerous and poorly studied organisms such as epiphytic lichens and bryophytes (Fazan *et al.*, 2022b), micromammifers, microarthropods and birds, but it also shapes the environment by providing shade and shelter to, as well as co-growing with numerous rare or endemic plants of the Cretan mountains.

Given the level of threat to various populations, *Z. abelicea* is protected by the Greek legislation (Presidential Decree 67/1981) forbidding the use and collection of any of its parts (Fournaraki and Thanos, 2006, Rackham and Moody, 1996) and is included in the Red Data Book (Phitos *et al.* 1995). It has been also classified as Endangered (EN) in the IUCN Red List of Threatened Species (Kozłowski *et al.*, 2012). It is listed on Annex II of the Habitats Directive and under Appendix 1 of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). Almost all the populations of the species are included in the Natura 2000 sites GR4320002, GR4320005, GR4330002, GR4330005 and GR4340008.

Overbrowsing by goats (21)



6. Last but not least

As you implement a conservation project, keep in mind the following points:

Be patient: Conservation is a process, not a product. It's a creative procedure and there is no cookbook for it.

Talk to many people: There are many elements and phases to conservation projects and many different views on how to accomplish them. Talk to a range of people to collect as much information as possible and to get different perspectives on the process.

Be flexible: Your ideas and goals may be clear at the outset, but for many reasons it may be best to change some, add some, and throw others out. As you go through the process, be flexible but keep your goals in mind.

Take your time: Try not to rush the process. Get the technical help you need. Get the permits required. Develop a community support base, where necessary.

Plan well: A well-considered and thorough plan will guide you through the project as directly as possible. A good plan will result in reasonable, measurable, and ecologically beneficial goals. A good plan will help you get funds and help.

Let reference sites be your guide: Reference sites are valuable models of what ecological conditions are achievable.

Use low impact implementation methods: Use soft techniques and passive methods whenever possible. Consider the impact of a construction and minimize those impacts.

Monitor and manage your site: Conservation does not end after the plants and structures are installed. All conservation projects must include monitoring to see if goals are being met and to direct the long-term adaptive management of the site.

Inspired from: "An introduction and user's guide to wetland restoration, creation, and enhancement: a guide for the public". Background information on project planning, implementation and monitoring (2003). <https://www.csu.edu/cerc/documents/AnIntroductionandUsersGuidetoWetlandsRestoration.pdf>.

7. References

- Bauer E.M., Bergmeier E. (2011). The mountain woodlands of western Crete – plant communities, forest goods, grazing impact and conservation. *Phytocoenologia* 41(2): 73-105.
- Carrera-Villacrés D.V., Robalino I.C., Rodriguez F.F., Sandoval W.R., Hidalgo D.L., Toulkeridis T. (2017). An innovative fog catcher system applied in the Andean communities of Ecuador. *Transactions of the American Society of Agriculture and Biological Engineers* 60(6): 1917-1923, <https://doi.org/10.13031/trans.12368>.
- Carrera-Villacrés D., Carrera Villacrés J.L., Braun T., Zhao Z., Gomez J., Quinteros-Carabali J. (2020). For harvesting and IoT based environment monitoring system at the Ilalo volcano in Ecuador. *International Journal on Advanced Science Engineering Information Technology* 10(1): 407-412.
- Christe C., Kozłowski G., Frey D., Bétrisey S., Maharramova E., Garfi G., Pirintzos S., Naciri Y. (2014). Footprints of past intensive diversification and structuring in the genus *Zelkova* (Ulmaceae) in south-western Eurasia. *Journal of Biogeography*, 41(6), 1081–1093. <https://doi.org/10.1111/jbi.12276>
- Dodson L.L., Bargach J. (2015). Harvesting fresh water from fog in rural Morocco: research and impact Dar Si Hmad's fogwater project in Ait Baamrane. *Procedia Engineering* 107: 186-193, <https://doi.org/10.1016/j.proeng.2015.06.073>
- Egli B. (1997). A project for the preservation of *Zelkova abelicea* (Ulmaceae), a threatened endemic tree species from the mountains of Crete. *Boccone* 5. 505-510
- Fazan L., Stoffel M., Frey D.J., Pirintzos S., Kozłowski G. (2012). Small does not mean young: Age estimation of severely browsed trees in anthropogenic Mediterranean landscapes. *Biological Conservation* 153: 97-100, doi.org/10.1016/j.biocon.2012.04.026
- Fazan L., Guillet S., Corona C., Kozłowski G., Stoffel M. (2017). Imprisoned in the Cretan mountains: How relict *Zelkova abelicea* (Ulmaceae) trees cope with Mediterranean climate. *Science of the Total Environment* 599-600: 797-805. doi.org/10.1016/j.scitotenv.2017.04.047
- Fazan L., Ghosn D., Remoundou I., Gotsiou P., Thanos C., Pasta S., Garfi G., Kozłowski G. (2021). Free behind bars: Effects of browsing exclusion on the growth and regeneration of *Zelkova abelicea*. *Forest Ecology and Management* 488: 118967. doi.org/10.1016/j.foreco.2021.118967
- Fazan L., Remoundou I., Ghosn D., Nikoli T., Pasta S., Garfi G., Kozłowski G. (2022). Understanding the factors influencing the growth of *Zelkova abelicea* in browsing exclosures. *Global Ecology and Conservation*. <https://doi.org/10.1016/j.gecco.2022.e02031>
- Fazan L., Certini D., Pasta S., Remoundou I., Ghosn D., Garfi G., Kozłowski G. (2022a). Trait variability in dispersal units and fruit of *Zelkova abelicea* (Ulmaceae) across its distribution range. [Under review - submitted to *Acta Oecologica*]
- Fazan L., Gwiazdowicz D., Fragnière Y., Fałtynowicz W., Ghosn D., Remoundou I., Rusińska A., Urbański P., Pasta S., Garfi G., Kozłowski G. (2022b). Factors influencing the diversity and distribution of epiphytic lichens and bryophytes on the relict tree *Zelkova abelicea* (Lam.) Boiss. (Ulmaceae) [accepted to *The Lichenologist*]
- Fournaraki C., Thanos C.A. (2002). Seeds of *Zelkova abelicea*, an endemic tree of Crete. *Book of Proceedings Tree Seeds Conference 11-15.09.2002*, Chania, Crete, Greece: 83-84.
- Fournaraki C., Thanos C.A. (2006). *Zelkova abelicea*, the unique endemic tree of Crete and its conservation. *ENSCONEWS* 1: 14-16.
- García D., Zamora R., Gómez J. M., Jordano P., Hódar J. A. (2000). Geographical variation in seed production, predation and abortion in *Juniperus communis* throughout its range in Europe. *Journal of Ecology*, 88(3), 436–446. <https://doi.org/10.1046/j.1365-2745.2000.00459.x>
- Garfi G. (1997). On the flowering of *Zelkova sicula* (Ulmaceae): additional description and comments. *Plant Biosystems* 131: 137-142
- Goedecke F., Bergmeier E. (2018). Ecology and potential distribution of the Cretan endemic tree species *Zelkova abelicea*. *Journal of Mediterranean Ecology* 16: 15-26

- Hampe A., Arroyo J. (2002). Recruitment and regeneration in populations of an endangered South Iberian Tertiary relict tree. *Biological Conservation*, 107(3), 263–271.
[https://doi.org/10.1016/S0006-3207\(02\)00061-7](https://doi.org/10.1016/S0006-3207(02)00061-7)
- Hampe A. (2005). Fecundity limits in *Frangula alnus* (Rhamnaceae) relict populations at the species? Southern range margin. *Oecologia*, 143(3), 377–386.
<https://doi.org/10.1007/s00442-004-1811-0>
- Hampe A., Petit R. J. (2005). Conserving biodiversity under climate change: the rear edge matters. *Ecology Letters*, 8(5), 461–467.
<https://doi.org/10.1111/j.1461-0248.2005.00739.x>
- Kozłowski G., Frey D., Fazan L., Egli B., Pirintsos S. (2012). *Zelkova abelicea*. In: IUCN 2012. IUCN Red List of Threatened Species Version 2012.2. www.iucnredlist.org
- Kozłowski G., Frey D., Fazan L., Egli B., Bétrisey S., Gratzfeld J., Garfi G., Pirintsos S. (2014). Tertiary relict tree *Zelkova abelicea* (Ulmaceae): distribution, population structure and conservation status. *Oryx* 48: 80-87,
doi.org/10.1017/S0030605312001275
- Kozłowski G., Bétrisey S., Song Y-G., Fazan L., Garfi G. (2018). The Red List of *Zelkova*. Natural History Museum Fribourg, Switzerland. 32pp
- Phitos D., Strid A., Snogerup S., Greuter W. (eds). 1995. The Red Data Book of Rare and Threatened Plants of Greece. WWF-Greece, Athens.
- Pinche C., Ruiz L. 1996. Fog on the brine – Fog-catching systems for arid lands. *WATERLINES* 14(4): 4-7.
- Rackham O., Moody J. (1996). The making of the Cretan landscape. Manchester University Press. 237pp.
- Sarlis G.P. (1987). *Zelkova abelicea* (Lam.) Boiss., an endemic species of Crete (Greece). *Webbia* 41: 247-255.
- Søndergaard P., Egli B. (2006). *Zelkova abelicea* (Ulmaceae) in Crete: floristics, ecology, propagation and threats. *Willdenowia* 36: 317-322.

8. Annex

Appeal for the enhancement of conservation measures of *Z. abelicea*



To: Office of the Prime Minister
Deputy Minister for Environmental Protection Issues,
Ministry of the Environment and Energy
Secretary General of Natural Environment & Water, Ministry
of the Environment and Energy
Natural Environment and Climate Change Agency (NECCA)
Governor of the Region of Crete
Municipalities of Crete

Subject: Appeal for the enhancement of conservation measures for the Cretan symbolic endemic tree *Zelkova abelicea* by reducing the grazing pressure on mountain ecosystems

Zelkova abelicea (common name: abelitsia) represents an emblematic endemic species of the Cretan mountain flora distributed in Lefka Ori, Psiloritis, Dikti and Thrypti, between 900 and 1800 m a.s.l.

The species is protected under Greek law (Presidential Decree 67/81), and most of its populations are found within the NATURA 2000 Network. Moreover, it is included in the Bern Convention and in Annexes II and IV of the European Habitats Directive (92/43/EEC).

According to the recent National report from the Greek Ministry of Environment and Climate Change to the European Commission, the species is reported in an unfavorable-inadequate conservation status. Moreover, according to the Law 1375B/7.4.2021 & Law 1915B/13.5.2021, Conservation Objectives for the species have been set, pointing out the need to increase the number of reproductive individuals of the species. In addition, *Z. abelicea* is listed as vulnerable in the Red Data Book of Greece and is classified as endangered on the IUCN Red List of Threatened Species.

Overgrazing by sheep and goats seems to pose the most important threat to the species as it prevents young individuals from developing into fully shaped, reproductive trees. Large arborescent trees of 5-20 m in height with a well-developed crown and bearing fruit are very rare and may represent only 5-6% of all known individuals. All other individuals are present in a dwarfed, bushy,

shrub-like form with multiple stems, dense growth and leaves <2 cm. Ecological studies show that the very dry summer climatic conditions as well as future climate change may also pose serious threats to the species.

Between 2014 and 2021, a project focused on the conservation of *Zelkova abelicea* was implemented (www.abelitsia.gr, www.zelkova.ch) by researchers of the University of Fribourg (Switzerland) and of the Mediterranean Agronomic Institute of Chania (CIHEAM-MAICh), with the support of the University of Athens and other European research Institutes, and of the Decentralized Administration of Crete -Forest Directorates (Chania, Rethymno, Iraklio, Lassithi). This project allowed to significantly increase our knowledge on the ecological requirements of *Z. abelicea*. All this knowledge, as well as genetic studies, can be used to write an ad hoc management plan and to identify the most urgent actions needed in order to improve the medium to long-term conservation of the species. Moreover, the project contributed to increasing public awareness through various dissemination and public sensitization actions.

The main results of the project were presented during a dedicated session of the 3rd Mediterranean Plant Conservation Week (www.medplantsweek.uicnmed.org/public_html/medplantsweek/en/3rd-mpcw/about-3rd-mpcv/), 27 September - 1 October 2021, held at the CIHEAM-MAICh, and co-organised by CIHEAM-MAICh and other international organisations such as the International Union for the Conservation of Nature (IUCN), bringing together many actors involved in plant conservation (i.e. representatives from universities, research institutes, gene banks, botanical gardens, parks, management bodies of protected areas, NGOs, etc.).

On behalf of the entire community of scientists and practitioners taking part in the 3rd MPCW, with the present document, we are asking that you adopt further measures to reduce the impact of overgrazing on the flora of the Cretan mountains and to bring in contact shepherds and State bodies in order to find some shared compromises and establish common actions to protect and safeguard some of the most important populations of *Z. abelicea*.

We hope that you will invest your role in creating the conditions for a better future for this plant and its ecosystem, a symbol for all Crete that all Cretans should know and protect, just like many other scientists and plant conservationists from Greece and other countries have been doing already for decades.

CIHEAM-MAICh, Chania, 1 October 2021

Bertrand de **Montmollin**,

Head of the Organizing Committee of the 3rd Mediterranean Plant Conservation Week
Head of the Mediterranean Plant Specialist Group (MPSG)
of the International Union for the Conservation of Nature (IUCN)

On behalf of the organizing committee of the 3rd Mediterranean Plant Conservation Week

Gianluigi Bacchetta

Universita' degli Studi di Cagliari, Italy and President
of Network of Mediterranean Plant Conservation
Centres - GENMEDA

Christini Fournaraki

CIHEAM-MAICh
Mediterranean Plant Conservation Unit

Pierre Carret

Critical Ecosystem Partnership
Fund - CEPF

Panagiota Gotsiou

CIHEAM-MAICh
Secretary of GENMEDA network

Recipients List

Office of the Prime Minister
primeminister@primeminister.gr

Deputy Minister for
Environmental Protection
Issues, Ministry of the
Environment and Energy
secdepmin.envr@ypen.gr

Secretary General of Natural
Environment & Water, Ministry
of the Environment and Energy
grggper@ypen.gr

Natural Environment and
Climate Change Agency
(NECCA)
info-ofypeka@prv.ypeka.gr

Governor of the Region of Crete
arnaoutakis@crete.gov.gr

MUNICIPALITIES OF CRETE

CHANIA
g-dimarchos@chania.gr
mayor@chania.gr

PLATANIAS
grammateia@platanias.gr
dimarxos@platanias.gr

SFAKIA
sfakia-d@otenet.gr

KISSAMOS
dkisamou@gmail.com

KANDANOS-SELINO
info@kantalouselinou.gr
dselinou@yahoo.gr

APOKORONAS
mayor@apokoronas.gov.gr
info@apokoronas.gov.gr

RETHYMNO
dimos@rethymno.gr

ANOGEIA
info@anogeia.gr
mkallergis@yahoo.gr

MYLOPOTAMOS
dimarxos@0456.syzefxis.gov.gr
perama1@otenet.gr

AGIOS VASSILIOS
gtatarakis@yahoo.gr
dimoslam@otenet.gr

AMARI
dim@amari.gov.gr

HERAKLION
mayor@heraklion.gr

PHAISTOS
mayor@moires.gov.gr
dmiron@otenet.gr

HERSONISSOS
dimos@hersonisos.gr

MALEVIZI
mayor@malevizi.gr

MINOAS PEDIADOS
mayor@minoapediadas.gr
minoas@minoapediadas.gr

GORTYNA
gortyna@0440.syzefxis.gov.gr
dimarxosgortynas@gmail.com

ARCHANES-ASTEROUSIA
mayor@0470.syzefxis.gov.gr

VIANNOS
dviannos@viannos.gr
dviannos@otenet.gr

AGIOS NIKOLAOS
grafdim@yahoo.gr

IERAPETRA
dimos@ierapetra.gov.gr

LASSITHI PLATEAU
istefanakis@yahoo.gr

SITEIA
dimarxos@sitia.gr
info@sitia.gr



PARTNERS



F O R E S T
D I R E C T O R A T E
C H A N I A
R E T H Y M N O
H E R A K L I O N
L A S I T H I



UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG

FINANCED BY

