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Guidelines and recommendations for the conservation of *Z. abelicea* in Crete
Final Project Workshop – 3rd MPCW, CIHEAM-MAICh, Chania 2021

Presentation Structure

1. Facts and information about *Z. abelicea*
2. Project background
3. Overview of field findings and lessons learnt
4. Conservation guidelines and recommendation measures

Partners

- CIHEAM-Mediterranean Agronomic Institute of Chania - Greece
- Decentralized Administration of Crete: Forest Directorates of Chania, Rethymnon, Heraklion and Lasithi - Greece
- University of Fribourg – Switzerland

In collaboration with

- Municipality of Platanias - Greece,
- National and Kapodistrian University of Athens - Greece,
- National Research Council, Institute of Biosciences and Bioresources, Palermo - Italy,
- Hellenic Agricultural Organization - Demetra - Laboratory of Forest Entomology

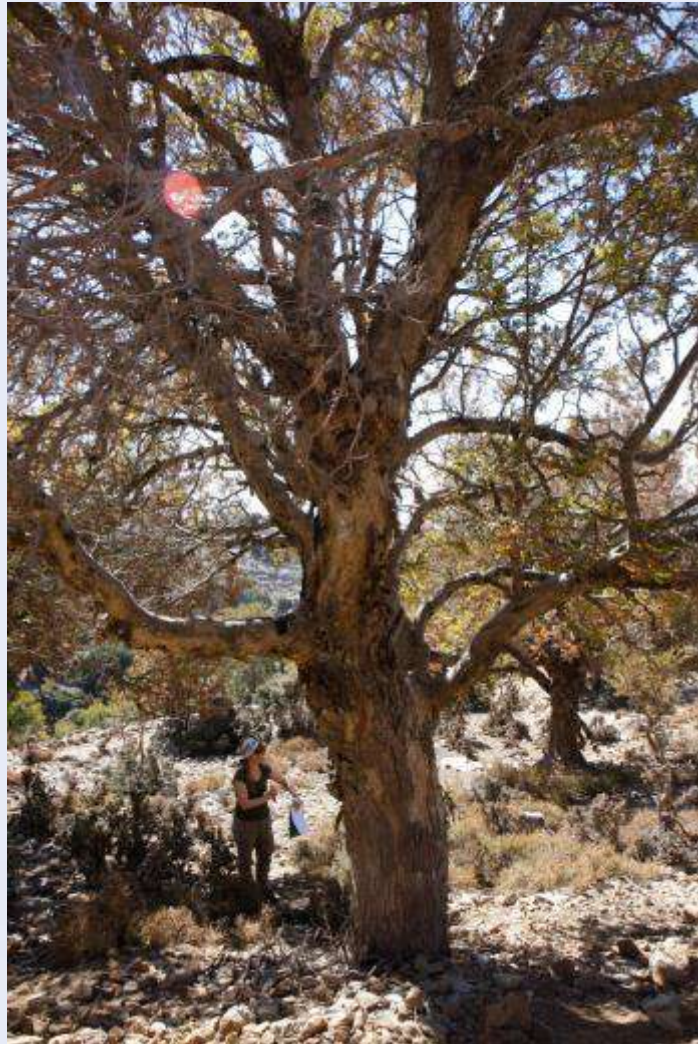
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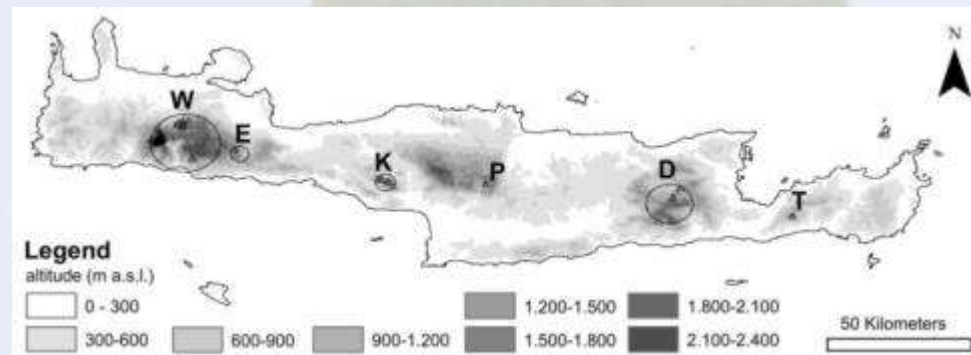


Conservation of *Zelkova abelicea* in Crete (2014-2021)

- ✓ ***Relict** deciduous tree species,
- ✓ Elm family (**Ulmaceae**),
- ✓ ***Endemic** to the island of Crete,
- ✓ Grows between 800 and 1800 m a.s.l. in association with *Acer sempervirens*, *Quercus coccifera* and occasionally *Cupressus sempervirens*,
- ✓ Fragmented distribution, confined to six spatially and genetically distinct populations,
- ✓ Flowering period April-May,
- ✓ Seeds mature October



Zelkova abelicea



Lefka Ori (West and East) , Kedros, Psiloritis, Dikti (South and katharo plateau), Thripti

***Relict:** is an organism that at an earlier time was abundant in a large area but now occurs at only one or a few small areas

***Endemic:** being unique to a defined geographic location, such as a country, an island or other defined zone, or habitat type

MAIN THREAT

Intensive Pastoral Activities



All populations are significantly threatened by **intensive pastoralism** mainly **overgrazing** and **browsing** by **goats** and **sheep** including **trampling**.

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Morphological Structure of *Z. abelicea*: **Dwarfed** and **Tree** Forms



Dwarfed form (non-flowering individuals ~ 95%)



Tree form (large and fruit-bearing trees ~ 5%)

As a result, all stands of *Z. abelicea* are dominated by dwarfed and heavily browsed individuals. Over **95%** of saplings across the island exhibit stunted, dwarfed, shrub-like form, while few individuals (~ **5%**) develop into fully shaped, **regularly fruiting trees**. This habit is especially pronounced in relatively small and isolated populations (e.g. in Thripti where no large trees are found at all).

Other Threats

Low Sexual Performance



Sound seed proportions are found to be very low and fluctuates strongly between populations (50-100% of seeds are empty).

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Seedlings' Survival in the Wild
is Very Low



Soil Erosion



Making Shepherds'
Walking Sticks

Patrimonial Value



- ✓ Holds a very strong **patrimonial value**, as traditional shepherd walking sticks (**katsounes**) are preferentially made with its hard, light and durable wood,
- ✓ **Pruning** of plants and **illegal collection** of wood hinders the growth and development of fruiting trees.



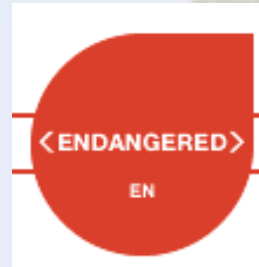
Conservation of *Zelkova abelicea* in Crete (2014-2021)



Zelkova abelicea

Given the level of threat, *Z. abelicea* has been:

- ✓ Classified as **Endangered** on the IUCN Red List of Threatened Species,



- ✓ **Protected** by the Greek legislation (Presidential Decree 67/1981), the Bern Convention (Appendix I) and is also included in Appendices II and IV of the European Habitats Directive (92/43).

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

Project background

2014



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 Frankinia (<https://fondationfrankinia.org/>); the CIHEAM-MAICh in collaboration with the four Forest Directorates of Crete (Chania, Rethymno Herakion and Lassithi) and the University of Fribourg initiated in 2014 a project entitled: ‘Conservation of *Z. abelicea* in Crete’.

Collaborative Conservation Project

www.abelitsia.gr

Overall objective: Enable, enhance and promote and the long term conservation of the species in Crete.

Conservation approach: Combining *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.

***In situ* Conservation Actions**

Fencing selected, small plots (5 x 5m – 10 x 10m) of *Z. abelicea* in ALL mountain massifs of Crete



- ✓ To protect *Zelkova* individuals' from grazing and browsing,
- ✓ To examine the effect of excluding grazing and browsing on the growth of the species,
- ✓ To understand factors influencing the growth of *Z. abelicea* in browsing exclosures

In total, 31 small plots have been fenced

14 in Lefka Ori, 4 in Mt. Kedros, 10 in Mt. Dikti and 3 Mt. Thripti

In situ Conservation Actions

In some areas, the effects of excluding browsing on *Z. abelicea* seemed to be less significant. This suggests that site-specific **biotic** and/or **abiotic** factors, such as precipitation, temperature and/or soil properties **could be additionally associated with these variations.**

- ✓ Online weather data from weather stations in the vicinity of established plots,
- ✓ Soil moisture/temperature, air temperature/humidity data from sensors and data-loggers installed within the plots,
- ✓ Soil data (soil properties)



Have been collected to investigate the relationship between abiotic factors and the Growth Rate of *Zelkova* individuals on different Mt. massifs.

Entomological Study Flies and Fruits

An unidentified Dipteran insect was recently observed to lay eggs on and affect the morphology of flowers of *Z. abelicea* by inducing gall formation.



Normal flowers and flowering shoot of *Z. abelicea*



Deformed flowers of *Z. abelicea* due to the presence of a Dipteran insect inducing gall formation



The yet unidentified dipteran species emerged from reared twigs of *Z. abelicea*. Eggs are inserted possibly as in the galls

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

Entomological Study Flies and Fruits



Insect fauna and flowers have been sampled to identify the unknown insect species and to understand **IF** and **HOW** this insect influence embryo development and/or fruits production and soundness.

Ex situ Conservation Actions

1- Fruit Collection, Curation and Storage



- ✓ Fruit collection (September - October) from all known populations of *Z. abelicea* bearing fruiting individuals,
- ✓ Parts of sound seeds are stored in the Seed bank of CIHEAM-MAICh, others are planted in the nursery for seedlings production,
- ✓ Propagated seedlings and plantlets are used in habitats restoration and/or *ex situ* plantations / public green spaces

Ex situ Conservation Actions

2- Propagation and cultivation of seedlings and cuttings



- ✓ Collection of vegetative materials (stolons and shoot cuttings),
- ✓ Treatment with different hormone concentrations for root formation

Ex situ Conservation Actions

3- Ex situ Plantation

An *ex situ* plantation was established in 2016 on public land offered by the Municipality of Platanias in Omalos (Lefka Ori). 400 young trees were planted in collaboration with students from a local primary school.



Omalos Plantation – Litter Removal, Soil Preparation and Planting

Communication and Outreach Activities



- ✓ Promote and advertise the values of *Zelkova abelicea* to the general public and influence decision-makers,
- ✓ Increase key stakeholders' understanding on the values, threats and pressures associated with *Zelkova* and the benefits of investing on its sustainable management,
- ✓ Raise the general public awareness on *Zelkova abelicea* and to encourage feedback and participation from local communities and various stakeholders.



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



Communication and Outreach Activities

- ✓ Development of a local project website,
- ✓ Implementation of information and environmental education events,
- ✓ Dissemination of communication material and project results



INTEGRATED CONSERVATION ACTIONS FOR THE RELICT AND ENDEMIC CRETAN TREE ZELKOVA ABELICEA (ULMACEAE)

THE SPECIES
Zelkova abelicea (Lam.) Boiss. is regarded as a rare species of the island flora endemic to the mountains of Crete (Greece) and is used to frame the traditional Cretan landscape (sky or sky-line). The species is classified as endangered on the IUCN Red List. Overgrowing by grass and thicket are self-renewing due to the presence of propagules (seeds and sprouts) in the soil. Important threats to the species: Only 25% of individuals are full-grown, with a well-developed crown and air to rise to 10m tall. All other individuals have a deformed structure morphology due mainly to overgrowing and air not freely. One tree individual can be very old (400 yrs), and the species often reproduces vegetatively via root suckering.

THE PROJECT
 In 2014 was launched a project for the conservation of *Z. abelicea* in cooperation between the Mediterranean Agronomic Institute of Chania, the "New Forest" Directorate of Crete and the University of Hohenheim (Germany), with actions aiming at:
 1) the implementation of all the measures for protecting *Z. abelicea* against its most important threats arising
 2) the ex situ conservation of all known populations of the species
 3) increasing public awareness
 The first phase of the project ended in 2014 and a second phase will extend until 2020.

ACTIONS & RESULTS FOR 2014-2016

In order to plan with 2 scientist individuals were hired throughout the mountains of Crete. Only small plots (2.5-3km²) were established to avoid deliberate destruction and minimize impact on land user activities. As soon as trees were identified, 2 scientist identified individuals began to grow and stronger and vegetation cover to change.

Public awareness and outreach actions for the preservation and education of the wide public on the importance of *Z. abelicea* conservation and the project actions are organized. The active involvement of local stakeholders is crucial for ensuring a positive outcome and a long-term sustainability of the project actions.

EX SITU PLANTS were collected from populations with fringing forest, old wood use properties were found in an very low (between 0.5m and 1.5m) and were collected from populations where there are no existing trees. In the vegetative propagation phase the success and further investigations are needed to produce more effective processes. The plants obtained here seeds or cuttings are used to establish ex situ collections in order to preserve the genetic diversity of the species. The first ex situ population was established in 2014 in public park offered by the Municipality of Iraklio in the Costa Dri. 50 young trees were planted by young of a local primary school.



Lakkois 2017 (West Crete)



Gerakari 2018 (Central Crete)



Kavousi 2017 (East Crete)

Field Findings and lessons learnt - *In situ* Conservation Actions

[Fazan et al. 2021a](#): 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

1- Tree growth

- ✓ Fencing small plots (20 - 100 m²) is efficient in allowing the protection and growth of *Z. abelicea* individuals,
- ✓ Small-scaled fencing proved to have a lower risk of being intentionally destroyed compared to large 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 trees grow faster than shorter individuals



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

Field Findings and lessons learnt - *In situ* Conservation Actions

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2- Seedlings survival

- ✓ Naturally established seedlings were found only in the Levka 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 was very rare, even in fenced areas, suggesting that the impact of summer drought could be of more importance than browsing pressure



Field Findings and lessons learnt - *In situ* Conservation Actions

Highlights on understanding the factors influencing the growth of *Z. abelicea* in browsing exclosures
([Fazan et al. 2021b](#): [Under review - Forest Ecology and Management](#))



- ✓ Spatial differences in growth rates of *Z. abelicea* trees exist between Cretan mountain ranges,
- ✓ Trees in the Levka 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 from Mt. Dikti and Thripti suffer more from water limiting climatic conditions than trees from the Levka 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

Field Findings and lessons learnt - *Ex situ* Conservation Actions

([MPCU - CIHEAM-MAICH](#))

- ✓ 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 Levka Ori populations),
- ✓ Fruit production follows a masting behavior (most fruiting trees produce fruit 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,
- ✓ 96% of *Z. abelicea* trees investigated from the Levka Ori had sound fruit,
- ✓ 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,



Field Findings and lessons learnt - *Ex situ* Conservation Actions

([MPCU - CIHEAM-MAICH](#))

- ✓ Vegetative propagation of shoot and root suckers revealed to have very low to null success, further investigations needed to develop a more effective protocol,
- ✓ Securing the preservation of the genetic variability of the species cannot rely only on the availability of plant material derived from fruits,
- ✓ *Z. abelicea* trees in the Levka Ori have a higher proportion of sound fruit than trees from central and eastern Crete ([Fazan et al. 2021c](#)),
- ✓ None of the investigated *Z. abelicea* trees from Mt. Psiloritis had sound fruits and only 20% of those from Dikti ([Fazan et al. 2021c](#)),
- ✓ A yet unknown Cecidomyiidae (Diptera) insect was found to form galls on *Z. abelicea* flowers and has been detected from several sites throughout the distribution range of the species ([Fazan et al. 2021c](#)),
- ✓ Trees with high quantities of galls produce less fruits, but fruit soundness is not impacted or influenced by gall presence or absence ([Fazan et al. 2021c](#)),

[Fazan et al. 2021c](#): The Cretan unique flying object: characteristics of the dispersal units of *Zelkova abelicea* (Ulmaceae) and their relationship with environmental drivers. [Manuscript under preparation]



Field Findings and lessons learnt - Communication and outreach activities



- ✓ Consensus and active involvement of local stakeholders and authorities is a prerequisite 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,
- ✓ 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



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



Conservation guidelines and recommendation measures

Guidelines and Recommendations that **we are going to discuss** further below are based on ALL above-mentioned field findings and lessons learnt. They could be used as support for the long-term conservation of *Z. abelicea* in Crete and **they will be addressed to National Authorities, decision makers, nature conservationists or anyone else interested in the conservation of the species.**

They are grouped into 4 different levels:

1. On the *in situ* level,
2. On the *ex situ* level,
3. On the communication and outreach level,
4. On the legal level



Conservation of *Zelkova abelicea* in Crete (2014-2020)



Conservation guidelines and recommendation measures *In situ* Level

***In situ* R1:** Increased efforts should be made towards the preservation of the **central and eastern *Z. abelicea* populations** since their long-term survival is jeopardized by **drought stress**,

***In situ* R2:** Focus on **fencing small-scaled (20 - 100 m²) plots** which are sufficient to allow regrowth of *Z. abelicea*. Small-scaled fences are less costly and strongly **reduce the risk of intentional destruction** compared to large fenced areas,

***In situ* R3:** Need to **actively involve local stakeholders** in the **selection of fenced plots**,

***In situ* R4:** Before fencing, **consider initial height** of *Z. abelicea* individuals, smaller individuals will take more time to grow than taller ones,

***In situ* R6:** Two to five years of fencing is sufficient to allow some individuals to reach a height at which they can escape browsing from goats, but this depends on initial tree height and growth rates,

***In situ* R7:** **Maintain and repair** (when and if 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,



Conservation of *Zelkova abelicea* in Crete (2014-2020)



Conservation guidelines and recommendation measures

In situ Level

***In situ* R8: Mini- fences** (30 x 30 x 30 cm) are an efficient and cheap way to protect newly established seedlings in the wild,

***In situ* R9: Monitor the growth** of *Z. abelicea* in all fenced plots **once every 3 years (?)**,

***In situ* R10: Long-term fencing of two (?) population areas (size of the area fenced?):** 1 population area in **eastern Crete** (Thripti?, the whole population? highly isolated and genetically unique population with no fruiting trees), AND and 1 in **western Crete** (Imbros? - trees from western and central Crete grow at higher rates than trees in eastern Crete),

***In situ* R11: Address the socio-economic needs of the local communities:** alternative activities targeting revenue generation mechanisms for local communities living in the vicinity of *Z. abelicea* populations should be identified and carried out. In order to reduce the overgrazing and over-browsing pressures, realistic and adequate alternative (eco-friendly) livelihood activities other than uncontrolled husbandry will need to be identified and implemented in parallel and as part of any *in situ* conservation effort of *Z. abelicea*. 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 to reduce the overgrazing and over-browsing pressures on the species and in such enable and enhance its natural regeneration,



Conservation of *Zelkova abelicea* in Crete (2014-2020)



Conservation guidelines and recommendation measures *In situ* Level

In situ R12: Invite the national and local authorities to revise their way of managing forested areas (theoretically a public/State property but indeed totally uncontrolled) by reducing the formal constraints and looking for medium-term agreements with local shepherd families (i.e. by proposing 10-years-long ownership/management contracts for precise and mapped areas and obliging the sheperds to respect the assigned boundaries and the sustainable browsing pressure measured in terms of herbivores/hectare, distinguishing the browsing-grazing species),

Research R1: Experiment watering or developing humidity capturing and maintenance devices (see Carrera-Villacrés et al. 2017, 2020, Dodson & Bargash 2015, Pinche & Ruiz 1996 and **monitoring of mature individuals** in the sites that were shown to be suffering more of drought stress (Psiloritis, Dikti and Thriпти (?) populations) in order to see if **these tools can increase the proportion of sound fruits**,

Research R2: Continue exploring the biodiversity associated with *Z. abelicea*,

Research R3: Update the conservation status of the species



Conservation of *Zelkova abelicea* in Crete (2014-2020)



Conservation guidelines and recommendation measures

Ex situ Level

***Ex situ* R1:** Collection, curation and storage of seeds: invest enough resources, time and manpower to **collect and sort seeds from populations with very low sound seed proportions,**

***Ex situ* R2:** Increase efforts to collect, curate and store seeds, especially from populations for which little or no seeds have been collected up to now (e.g. **southern side of the Levka Ori, central and eastern Crete populations**),

***Ex situ* R3:** Dedicate part of the seed collection for the production of plant materials, to guarantee when needed, the availability of seedlings for use in recovery/restoration plans,

***Ex situ* R4:** Continue aftercare (**pruning, weeding**) of *Z. abelicea* seedlings in the **Omalos plantation** that provides a recreation and education outdoor space for local schools and wider visiting public. On the long term, this plantation could provide “certified” alternative source for making traditional “katsounes” (shepherds walking sticks),

Research R4: Develop an efficient **vegetative propagation protocol** and propagate plant materials from shoot or root cuttings, as well as through **micropropagation techniques**, mainly for populations for which low to null seed soundness are known (i.e. the **central and eastern populations**)



Conservation of *Zelkova abelicea* in Crete (2014-2020)



Conservation guidelines and recommendation measures Communication and Outreach Level

C & O R1: Involve all key stakeholders in the decision-making process,

C & O R2: Use strategic communication channels, materials and activities to support effective public participation and improve public awareness in relation to the species and its habitat,

C & O R3: 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,

C & O R4: Maintain and repair (when and if needed) information signs installed at the main squares of villages located near *Z. abelicea* natural stands,

C & O R5: Organize environmental education and information campaigns related to *Z. abelicea* at the exhibition center of the CIHEAM-MAICh in the form of student-weeks once per year,

C & O R6: Continue with media publicity and dissemination of communication materials at the local and regional levels

Conservation of *Zelkova abelicea* in Crete (2014-2020)

Conservation guidelines and recommendation measures Legal Level

Legal R1: Improve the legal protection status of the species (?) How (?),

By establishing and legally securing Plant Micro-Reserves (?) or any other type of relevant legal protection (?) in two or more population areas (?)

Are PMRs for *Z. abelicea* achievable and practical (?) **If YES**: where (?) and size of the area (?)

- 1 PMR in eastern Crete (**Thripti - Psiloritis**) (?)
- 1 PMR in western Crete (**Imbros**) (?)
- Legal measures for the restriction of livestock activities in the PMRs (?)

If PMRs are NOT achievable and practical, any other type of relevant legal protection (?)

Actions for the establishment of the PMRs or any other type of relevant legal protection should be initiated in cooperation with the Decentralized Administration of Crete, the local Forest Directorates, local Municipalities and local users of land.

Thank you

conservation actions 2014 - 2020

In situ conservation actions

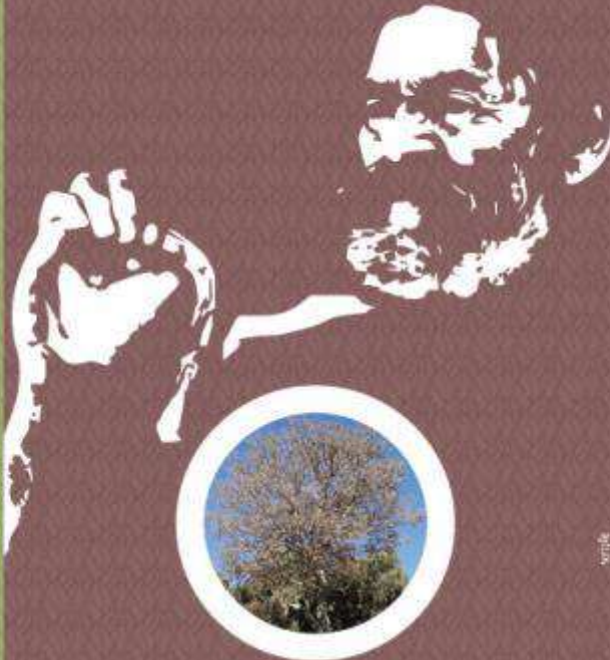
- Fencing selected trees or plots in all mountain massifs of Crete (Lefka Ori, Kedros, Dikti, and Thripti).
- Monitoring the growth of *Z. abelicea* and other woody species as well as vegetation changes within fenced plots.
- Investigating the effect of abiotic (rainfall, air and soil temperature, air and soil humidity) and biotic (entomological) factors on the growth of the species.

Ex situ conservation actions

- Seed collection, curation, germination experiments and storage in MAICH seed bank.
- Vegetative propagation and nursery works.
- *Ex situ* plantations.

Public awareness and outreach

- Promote the values of *Zelkova abelicea* to the general public and influence decision-makers.
- Raise general public awareness on *Zelkova abelicea* and encourage feedback and participation from local communities and various stakeholders.



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- National and Kapodistrian University of Athens, Faculty of Biology, Department of Botany
- University of Fribourg & Natural History Museum Fribourg
- National Research Council, Institute of Biosciences and BioResources, Palermo - Italy

Associated Partners:

- Hellenic Agricultural Organization - "Demetra" / Institute of Mediterranean Forest Ecosystems, Laboratory of Forest Entomology
- Municipality of Platanias - Chania



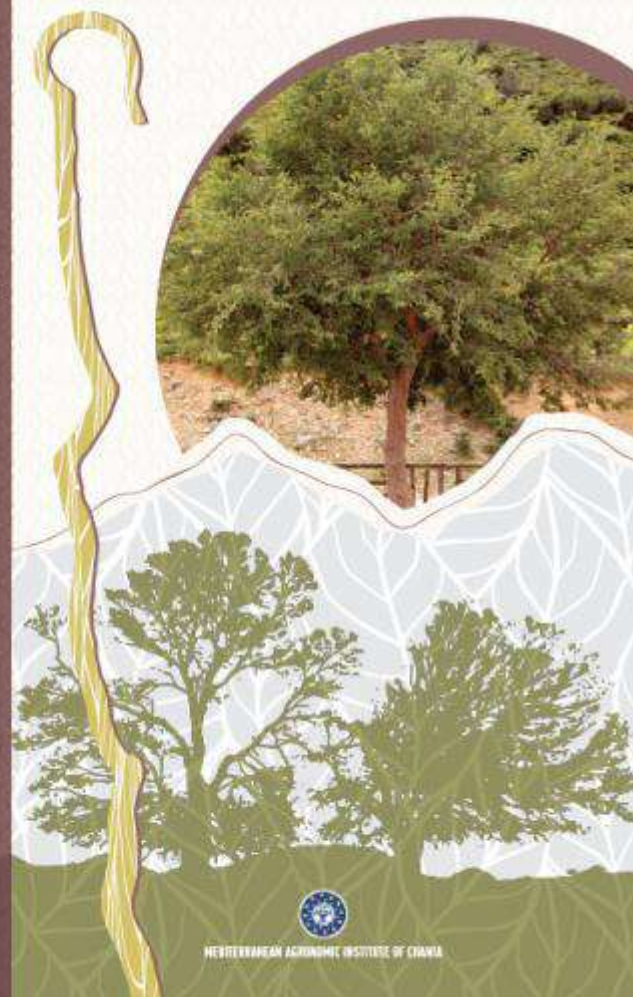
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ΑΛΕΞΙΟΥ



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Zelkova abelicea

the threatened, endemic
tree of Crete



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