

# The Red List of Zelkova

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Laurence Fazan - Giuseppe Garfi



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*Zelkova abelicea*, Dikti Mountains, Crete (gk)

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**NATURAL HISTORY MUSEUM FRIBOURG (NHMF)**, is part of the Department of Education, Culture and Sport of the State of Fribourg (Switzerland). Created in 1824, the NHMF is one of the oldest museums in the country. Boasting a long history, first-rate curatorial expertise and diverse collections, the museum is a leading institution in conservation. Since its inception, the NHMF has actively participated in numerous national and international research and conservation programmes focusing in particular on alpine and aquatic plants and, more recently, relict flora.



**BOTANIC GARDEN OF THE UNIVERSITY OF FRIBOURG (BGFR)**, Switzerland, is a centre of expertise for the scientific study and conservation of relict trees. The BGFR also leads a number of basic and applied national and international research and conservation projects on various biological and biogeographical aspects of aquatic, alpine and endemic plants. It also created and coordinates the *Zelkova* and *Pterocarya* global projects.



**SHANGHAI CHENSHAN BOTANICAL GARDEN (SCBG) / SHANGHAI CHENSHAN PLANT SCIENCE RESEARCH CENTRE (SCPSRC) / CHINESE ACADEMY OF SCIENCES (CAS)**. In October 2009, the Chinese Academy of Sciences (CAS) and the Shanghai Municipality Government created the Shanghai Chenshan Plant Science Research Centre, a nonprofit institution focusing on plant science research. It provides scientific and technological support for the development of the Shanghai Chenshan Botanic Garden. The mission of the centre is to preserve plants in eastern China, to discover ways of using them sustainably and to inform and motivate the general public.



**INSTITUTE OF BIOSCIENCES AND BIORESOURCES (IBBR)** is part of the National Research Council (CNR), which is the most important research organization in Italy. The research activity of the IBBR-Division of Palermo mainly focuses on the improvement of plant genetics, the characterization of plant genetic diversity, and tissue culture for virus- and bacteria-free propagation through somatic embryogenesis. IBBR is also actively involved in the conservation of plant germplasm from rare and threatened cultivated and wild species.



**MEDITERRANEAN AGRONOMIC INSTITUTE OF CHANIA (CIHEAM-MAICH)** is the 4th constituent Institute of the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), an intergovernmental organization devoted to the sustainable development of agriculture and fisheries, food and nutrition security and rural and coastal areas. Since 1986, the CIHEAM-MAICH has pursued its three main complementary missions through: (1) specialized post-graduate education; (2) networked research; and (3) facilitation of regional debate with a focus on the fields of business economics and management, geoinformation in environmental management, horticultural genetics and biotechnology, food quality and the chemistry of natural products and sustainable agriculture.



**CONSERVATOIRE & JARDIN BOTANQUES OF THE CITY OF GENEVA (CJBG)** are among the ten largest botanical institutions in the world due to their 6 million herbarium specimens and their outstanding living collections. The CJBG lead research activities in floristics, plant and fungal systematics as well as in conservation. The research facilities include four different laboratories dealing with genetics, anatomy and micromorphology, microscopy, and chromatography as well as GIS and remote sensing. These facilities are linked to the University of Geneva, where several CJBG researchers lecture on a regular basis in botany, systematics, biodiversity, anatomy and genetics.



**IUCN/SSC GLOBAL TREE SPECIALIST GROUP (GTSG)** forms part of the Species Survival Commission's network of over 7,000 volunteers working to stop the loss of plants, animals and their habitats. The SSC is the largest of the six Commissions of IUCN (the International Union for Conservation of Nature). It serves as the main source of advice to the Union and its members on the technical aspects of species conservation. The aims of the IUCN/SSC Global Tree Specialist Group are to promote and implement the global red listing of trees and to act in an advisory capacity to the Global Trees Campaign.



**BOTANIC GARDENS CONSERVATION INTERNATIONAL (BGCI)** is a global network linking botanic gardens and other conservation organisations in over 100 countries in a shared commitment to the conservation of plant diversity, sustainable use and environmental education. BGCI provides the Secretariat to the IUCN/SSC Global Tree Specialist Group and is a partner in the Global Trees Campaign, a joint initiative among Fauna & Flora International, BGCI and a wide range of other organizations dedicated to saving the world's threatened trees for future generations.



A mixed forest of *Quercus coccifera*, *Acer sempervirens* and *Zelkova abelicea* in the Dikti Mountains in Crete, Greece [gk]



# Foreword

## DR. PIERRE-ANDRÉ LOIZEAU

Director

Conservatoire et Jardin botaniques de la Ville de Genève (CJBG)

The *Zelkova* Project is exceptional, as it combines many fields of study in order to answer the question of emblematic tree species survival. Indeed, the genus *Zelkova*, an Ulmaceae, comprises of rare relict species, which are currently threatened. Despite this relative seniority, the species *Zelkova sicula* Di Pasq., Garfi & Quézel was only described in 1991 in Sicily. This shows just how many secrets our planet still has to reveal to us. This will only be possible if the “untamed” nature is respected and protected, so as not to destroy what we do not yet know. It is not only a question of usefulness for the human being; it is also an ethical issue in relation to the living. This is the first lesson I learn from this work.

The second lesson is linked to the study of *Z. abelicea* (Lam.) Boiss. for which population genetic studies have shown an intraspecific diversity linked to the existence of isolated populations in the mountains of Crete. Yet, this species is relatively well represented in botanical gardens. It should be noted that the BGCI has estimated that nearly a third of the wild species were cultivated in the approximately 3500 botanical gardens covering the world. This observation gives us some hope of finding in these institutions the means to conserve endangered species. However, the study of *Z. abelicea* also focused on the representation of this species in botanic gardens, and thus demonstrated that the individuals came from a very limited number of sites, far from covering the intraspecific diversity observed in Crete. This clearly demonstrates that conservation programmes should, as much as possible, ensure some intraspecific variability in order to respect the ecotypes and maintain a sufficient dynamism of reintroduced populations.

To conclude, I would like to pay tribute to the work of Prof. Dr. Gregor Kozłowski, from the Biology Department and Botanic Garden of the University of Fribourg, who led this project since 2010 with commitment and efficiency. He managed to federate around this study many institutions and many scientists, producing large number of contributions to books, scientific articles, articles for the general public and conferences. The project not only focused on the scientific study, which is essential for assessing threat status, but also suggested and led action plans, trained students, developed exhibitions and built iconographic databases. This represents for me an exemplary project, of which this Red List is one of the remarkable and essential products.

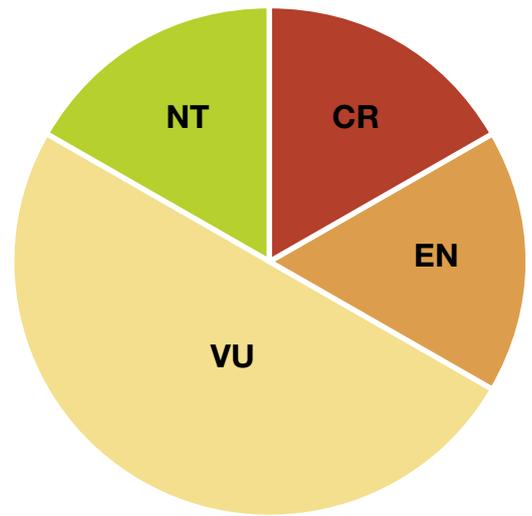
# Global conservation status of *Zelkova*: an overview

## RELICT TREE GENUS *ZELKOVA*: SHORT PRESENTATION

*Zelkova* is a small genus of relict trees belonging to the elm family (Ulmaceae). Species of *Zelkova* were important elements of the vast forests that prevailed throughout the Northern Hemisphere during much of the Cenozoic Era. Today, the genus comprises six extant species with a disjunct distribution pattern: three species in East Asia (*Z. serrata*, *Z. schneideriana* and *Z. sinica*), one species in Southwest Asia (*Z. carpinifolia*) and two species on the Mediterranean islands of Sicily (*Z. sicula*) and Crete (*Z. abelicea*).

## THREAT STATUS OF *ZELKOVA*

All six *Zelkova* species were recently assessed using IUCN methodology: *Z. abelicea* in 2012, *Z. sicula* in 2017 and the remaining four species in 2018. All but one species (83%) are considered globally threatened (CR, EN, or VU). *Zelkova sicula* is Critically Endangered (CR), *Zelkova abelicea* is Endangered (EN) and three species are Vulnerable (VU): *Z. carpinifolia*, *Z. schneideriana* and *Z. sinica*. The only species not threatened (*Z. serrata*) was assessed as Near Threatened (NT).



1. Isolated and poorly studied populations of *Zelkova serrata* on the Jeju island in South Korea (ek)

2. *In situ* conservation through fencing of *Zelkova sicula* in Sicily, Italy (gk)

3. Overbrowsing by goats is one of the main threats to *Zelkova abelicea* in Crete (gk)

4. Fire is an important threat to both of the Mediterranean *Zelkova* species (Mt. Kedros, Crete, Greece) (gk)

## COUNTRY ANALYSIS

The genus *Zelkova* is distributed across 12 countries. China has the most species (*Z. serrata*, *Z. schneideriana* and *Z. sinica*). *Zelkova* species have been recorded from 17 Chinese provinces with Henan, Hubei and Shaanxi Provinces each possessing all three species. *Zelkova sinica* is a Chinese endemic, whereas *Z. schneideriana* is found both in China and on Taiwan. All other countries have only one species. Japan and South and North Korea each have *Z. serrata*, and Taiwan probably has only *Z. schneideriana*. *Zelkova carpinifolia* is known from 5 countries in the Transcaucasian region (Georgia, Turkey, Armenia, Azerbaijan and Iran). *Zelkova sicula* is endemic to Sicily (Italy) and *Z. abelicea* is endemic to Crete (Greece).

## MAJOR THREATS TO ZELKOVA

The most commonly recorded threat to the genus is anthropogenic habitat fragmentation and the resulting geographic isolation of subpopulations as well as a very low rate of natural regeneration and high seedling mortality. For the East Asiatic and Transcaucasian *Zelkova* species, logging as well as habitat loss due to urban sprawl and/or the conversion to agricultural land have been and remain very significant threats in certain regions. The majority of *Zelkova* species typically produces minute quantities of viable seeds; this is particularly true for *Z. abelicea*. *Zelkova sicula* is an extreme case within the genus. It is a triploid taxon that reproduces exclusively by vegetative means. The two known stands of this taxon are in fact two single individuals with extremely low genetic diversity. In addition, *Z. abelicea* is severely threatened by ovine and caprine presence (overbrowsing, trampling, etc.), and bovine browsing has been documented for *Z. carpinifolia* (as well as for *Z. sicula*, historically). In the Mediterranean, drought and wildfires are also recorded as posing a risk to a number of populations. Finally, for *Z. schneideriana* and *Z. sinica* in China, extensive plantations and the spread of invasive species have been documented as problematic for the conservation of these rare species.



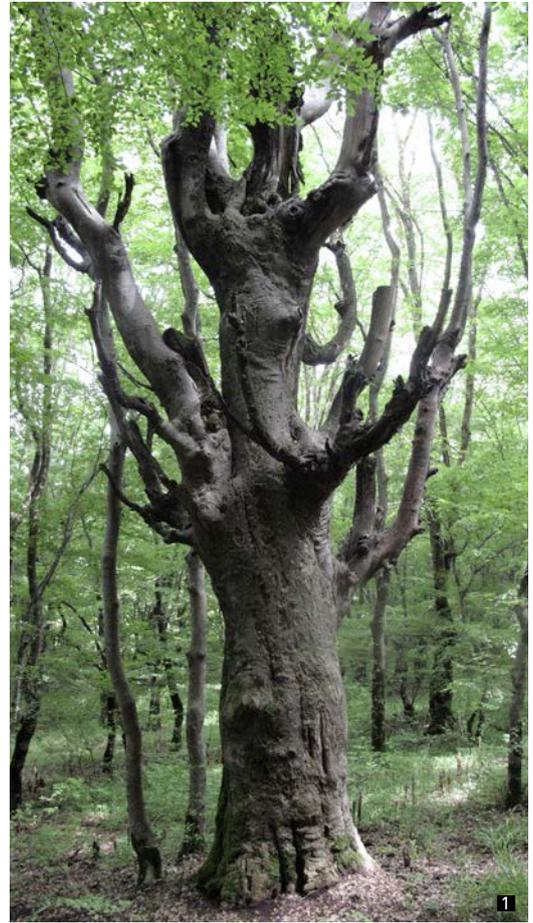
Threat	<i>Z. sicula</i>	<i>Z. abelicea</i>	<i>Z. carpinifolia</i>	<i>Z. serrata</i>	<i>Z. schneideriana</i>	<i>Z. sinica</i>
Fragmentation, isolated subpopulations	X	X	X	X	X	X
Low natural regeneration, high seedling mortality	X	X	X	X	X	X
Small quantities of viable seeds, seed sterility	X	X	X	-	X	X
Extensive logging/wood harvesting	-	-	X	X	X	X
Habitat loss, urbanization, agriculture	-	-	X	X	X	X
Pastoral activities (overbrowsing, trampling)	(X)	X	X	-	-	-
Drought	X	X	-	-	-	-
Fires	X	X	-	-	-	-
Plantations	-	-	-	-	X	X
Invasive species	-	-	-	-	X	-

(X) Historically or very sporadically



## USES

Five *Zelkova* species have an identified use. Within the genus, only *Z. sicula* is not known to have any direct use (in whole or in part). Discovered only in 1991, natural populations of *Z. sicula* consist mainly of small shrubs, and the species has probably remained unknown to the local people. In contrast, the East Asiatic and Transcaucasian species (*Z. serrata*, *Z. schneideriana*, *Z. sinica* and *Z. carpinifolia*) very often grow to be large trees and sometimes form monospecific stands and are used for wood harvesting and timber production for the construction and furniture industries. Their wood is heavy, hard and resistant to decay, reddish and visually attractive, and thus expensive and highly sought in Asia. In medieval Japan, for example, *Z. serrata* was the primary tree used for making battleships. Additionally, *Z. carpinifolia* was used for charcoal production. Asiatic *Zelkova* species are very popular as ornamental trees in urban areas, parks, monasteries, etc. This is particularly true of *Z. serrata* in Japan, where it is a common forest tree that is planted commercially and ornamentally across the country. It is also one of the most popular bonsai trees in Japan. The East Asiatic species are also used in traditional and modern medicine (e.g., leaves are externally applied to wounds as a poultice or leaf and bark extracts are used in cancer treatments). In some regions with pastoral traditions, the leaves and young branches are used as stock fodder (*Z. carpinifolia* and *Z. abelicea*) and their wood is used for handicrafts. One of the best known examples of traditional use of *Zelkova* wood comes from Crete, where *Z. abelicea* branches are used to make katsounes (shepherd walking sticks). The bark and wood of *Z. schneideriana* is locally used in China for rope and paper production, and the leaves and bark of *Z. carpinifolia* are used in Azerbaijan for dyeing wool. Finally, in Japan, young leaves of *Z. serrata* are cooked as vegetables.



Uses	<i>Z. sicula</i>	<i>Z. abelicea</i>	<i>Z. carpinifolia</i>	<i>Z. serrata</i>	<i>Z. schneideriana</i>	<i>Z. sinica</i>
Construction, timber, firewood	-	(X)	X	X	X	X
Medicine	-	-	X	X	X	X
Landscape architecture, parks	-	-	X	X	X	-
Handicrafts	-	X	X	X	-	-
Stock fodder	-	X	X	-	-	-
Ropes	-	-	-	-	X	-
Paper	-	-	-	-	X	-
Dyeing	-	-	X	-	-	-
Charcoal production	-	-	X	-	-	-
Food (leaves)	-	-	-	X	-	-

(X) Historically or very sporadically



## EX SITU COLLECTIONS

An extensive survey was undertaken in 2010 to assess the conservation status of all six *Zelkova* species in *ex situ* collections worldwide (for more details, see Kozłowski et al. 2012 as well as the “Global survey of *Zelkova ex situ* collections”, available online at [www.bgci.org](http://www.bgci.org)). In total, 255 records of *Zelkova* from 137 botanic gardens and arboreta in 27 countries were identified. However, the results of these studies revealed major gaps, both in the extent and in the quality of the collections. Although all *Zelkova* taxa are found in botanic gardens and arboreta, few collections exist in the countries of the species’ natural occurrence. More importantly, the *Zelkova* species that are most at risk are also the least represented in botanic garden collections and are thus inadequately safeguarded through *ex situ* conservation. Only 10% of all known *ex situ* collections of the genus consist of the acutely threatened Mediterranean *Z. sicula* and *Z. abelicea*, or *Z. sinica*, which has the smallest distributional range of all East Asiatic *Zelkova* species and is the least represented in Chinese *ex situ* collections. Furthermore, more than 80% of all *Zelkova ex situ* collections are poorly documented; not only is the origin of the plant material unknown, but its taxonomic status and/or the cultivation history is often uncertain. Additionally, *Zelkova ex situ* collections are generally small, with 90% of holdings comprising either one individual or a maximum of two to ten trees.



1. A pollarded individual of *Zelkova carpinifolia* in the Babaneuri Nature Reserve (Georgia) (gk)

2. *Zelkova abelicea* branches are used in Crete (Greece) to make katsounes (shepherd walking sticks) (lf)

3. *Zelkova serrata* is one of the most popular ornamental trees in Japan (Tokyo, Japan) (ek)

4. A *Zelkova serrata* planted forest in the Chichibu Mountains (Japan) (sb)





A *Zelkova serrata* population in the Todoroki valley (Tokyo, Japan) (ek)



*Zelkova* species assessments

# *Zelkova sicula* Di Pasq., Garfi & Quézel

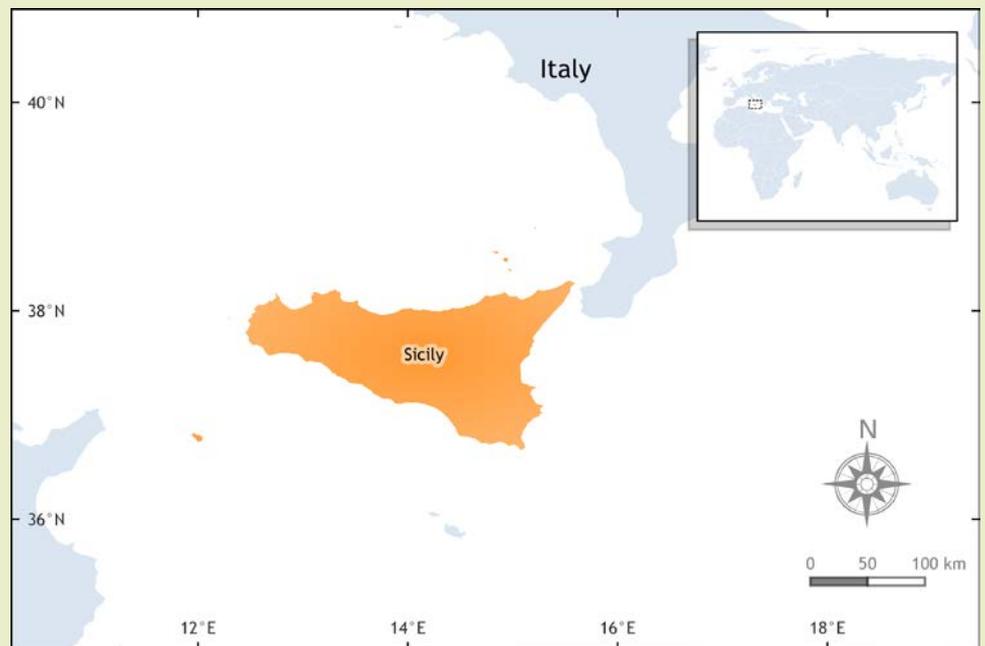
## Sicilian Zelkova

Italy (Sicily)

Critically Endangered **CR**

B1ab(iii)+2ab(iii)

Year of evaluation: 2017



### DISTRIBUTION

*Zelkova sicula* is an endemic tree from Sicily and the rarest representative of the genus. It is restricted to the volcanic outcrops of the Iblei Mountains in southeastern Sicily (province Siracusa, municipalities of Buccheri and Melilli). Since 2016, four new populations currently consisting of ca. 45 plants each have been established according to the principles of assisted colonisation. The new populations are located in the mountainous areas of regional parks in the Nebrodi Mts., the Madonie Mts., the Sicani Mts., and in the Bosco Pisano; the latter population is only several hundred metres from one of the native populations.

**E00** (extent of occurrence): 8 km<sup>2</sup>

**A00** (area of occupancy): 8 km<sup>2</sup>

### NUMBER OF SUBPOPULATIONS

*Zelkova sicula* consists of only two native subpopulations in addition to the four new subpopulations established since 2016 through assisted colonisation.

### HABITAT

The species mainly grows in gully bottoms in the thermo-Mediterranean belt within scattered evergreen forests between 318 and 526 m a.s.l. Three of the new subpopulations were established in a more mesophylous habitat within temperate forests of mixed deciduous broadleaf trees located from 1,014 to 1,341 m a.s.l.

### THREATS

The main threats to *Z. sicula* are ineffective sexual propagation (seed sterility) and the resulting genetic impoverishment as well as the significant increase in summer drought stress and wildfires that are presumably the result of climate change.

### URGENT ACTIONS NEEDED

- > New reintroduction actions based on the principles of assisted colonisation.
- > Enhanced *ex situ* collections.
- > Improved knowledge of reproductive biology, ecological requirements (soil and water) and ecosystem-level relationships (competition, facilitation, parasites and predators).
- > Field exploration throughout Sicily supported by modern GIS and remote sensing tools to locate new populations, which may contain precious genetic diversity to be conserved.



**1.** The two natural populations grow in suboptimal climatic conditions. The recurring summer drought stress and the forecasted climate change represent the major threats for the survival of the species (gg)

**2.** *Zelkova sicula* probably escaped extinction in Sicily by "hiding" in thalwegs, where an underground water supply could mitigate the deficits in rainfall (gg)

**3.** There are only two known, small stands worldwide; thus, any accidental event, such as repeated wildfires over short time periods, could wipe out the species entirely (gg)

**4.** However, the species is a master of survival, defying environmental changes and human impact for millennia (or even millions of years), likely due to its high resilience and great ability to undergo vegetative regeneration (gg)

**5.** Since *Zelkova sicula* is sterile due to its triploid karyotype, the most effective method to multiply the species is through *in vitro* cultures. The newly produced plantlets are used for *in situ* and *ex situ* conservation programmes (ac)

**6.** Assisted colonisation seems to be one of the most efficient methods for the long-term conservation of the species. Being adopted, to date, only for a limited number of plant species, assisted colonisation continues to be a pioneering approach in Europe that, in the case of *Zelkova sicula*, appears very promising (gg)



# *Zelkova abelicea* (Lam.) Boiss.

Cretan Zelkova

Greece (Crete)

Endangered **EN**

B1ab(iii)+2ab(iii)

Year of evaluation: 2012



## DISTRIBUTION

*Zelkova abelicea* is endemic to the Greek island of Crete. It has a fragmented distribution throughout all mountainous areas (Levka Ori, Kedros, Psiloritis, Dikti, Thripti) of Crete.

**EOO** (extent of occurrence): 2,094 km<sup>2</sup>

**AOO** (area of occupancy): 64 km<sup>2</sup>

## NUMBER OF SUBPOPULATIONS

The total population of *Z. abelicea* is estimated to be composed of more than 1,000,000 individuals distributed in eight to ten main subpopulations that can reproduce asexually via root suckering to produce clones. Only an estimated 20,000 individuals bear fruit and most of these have inviable seeds. Therefore, the effective population size of sexually reproducing individuals may be much lower than estimated.

## HABITAT

*Zelkova abelicea* grows between 800 and 1,800 m a.s.l. in or around karstic sinkholes, rocky slopes, along gullies or temporary rivers and most often on north-facing slopes. However, particularly along the upper limit of the elevational distribution, stands can also be found on south-facing slopes.

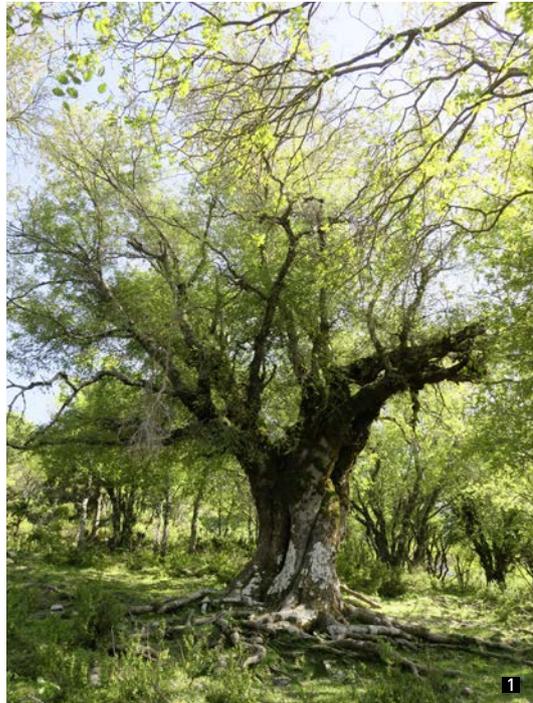
## THREATS

*Zelkova abelicea* shows a low and slow regeneration rate in the wild mainly due to overbrowsing and trampling by goats, and habitat deterioration by both ovine and caprine flocks as well as dry, unfavourable summer conditions. Currently, seedlings rarely establish and survive in the wild, and individuals derived from clonal regeneration grow very slowly and can have difficulty attaining an adequate height to escape browsing and produce fruit. Due to changes in flock management practices and EU funding policies, browsing pressure has increased in most areas over the last 50 years. Individuals grow in highly fragmented and isolated stands and at present, some subpopulations contain no sexually mature individuals. Trees produce fruit in cyclic 2-3 year masting events, however, most fruits have inviable seeds. Population trends are estimated to be stable mainly due to the production of clones through root suckering. However, the imbalance between the number of fruiting and non-fruiting individuals is expected to increase in the future with the natural death of old fruit-bearing trees and the inability of other individuals to escape their dwarfed and overbrowsed, non-fruiting state.

## URGENT ACTIONS NEEDED

- > Continue current conservation efforts (*in situ* and *ex situ* conservation actions and public awareness activities, project details at [www.abelitsia.gr](http://www.abelitsia.gr)).
- > Develop efficient protocols for *ex situ* propagation and enhance *ex situ* collections.
- > Enhance seedling survival rates in the wild with efficient conservation actions.
- > Improve knowledge of reproductive biology, ecological (soil and water) requirements and ecosystem-level relationships (competition, facilitation, parasites and predators).

1. A very ancient *Zelkova abelicea* individual. These old trees, with their gnarled forms, stand as witnesses to past human activities, such as pollarding, and give shelter to numerous organisms by harbouring unique and complex ecosystems. They are also important sources of thousands of seeds that may become the trees of tomorrow (lf)



2. This isolated subpopulation of *Zelkova abelicea* comprises the easternmost representatives of the species. Located in a remote sinkhole in eastern Crete, it is composed solely of a few dozen dwarfed individuals. In the absence of fruiting trees, the individuals propagate solely by vegetative means through root suckering (lf)



3. *In situ* conservation measures include setting up small, fenced enclosures to protect *Zelkova abelicea* individuals from overbrowsing and trampling by flocks. In some areas, the changes in vegetation cover are striking. Seedlings and a large variety of plants also benefit from the exclusion of browsers (lf)

4.-5. Overgrazing by ovine and caprine flocks (lf)



6. Information events are very important in sensibilising new generations. Primary school children in the information centre of the Samaria Gorge National Park (cm)



7. Collecting fruits for *ex situ* conservation of *Zelkova abelicea* (cm)

# *Zelkova carpinifolia* (Pall.) K. Koch

## Caucasian Zelkova

Iran, Azerbaijan, Armenia, Georgia, Turkey

Vulnerable   
A2cd  
Year of evaluation: 2018



### DISTRIBUTION

*Zelkova carpinifolia* is one of the most emblematic relict trees in the Colchic and Hyrcanian forests. Two main centres of distribution can be distinguished: the first is along the Alborz Mountains in Iran and the Talysh Mountains in Azerbaijan, and the second is in western Georgia. Outside these regions, a few isolated and fragmented localities are also known from the Karabakh Mountains, northwestern and eastern Georgia, Armenia and Anatolia in Turkey. However, the species is very rare outside Iran.

**EOO** (extent of occurrence): 755,025 km<sup>2</sup>

**AOO** (area of occupancy): > 600 km<sup>2</sup>

### NUMBER OF SUBPOPULATIONS

Only a few dozens subpopulations still exist outside Iran, where the majority of the distribution occurs. The total number of subpopulations is estimated to be around 100.

### HABITAT

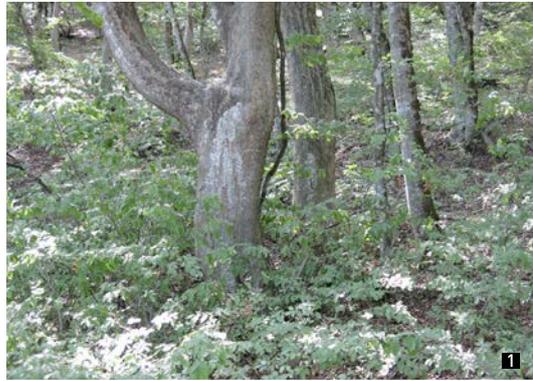
*Zelkova carpinifolia* is a typical element of mixed broad-leaved forests and riparian forests, although the tree avoids waterlogged conditions. The species is also known to form pure stands in the Hyrcanian area. The elevational range of the species lies mainly between 100 and 600 m a.s.l. with some localities situated between 1,200 and 1,550 m a.s.l.

### THREATS

The main threats to the species result from the extensive logging of this valuable tree across its entire distribution during the last century. The original forests in the Colchis and in the Hyrcanian regions have been reduced drastically with a very high impact on this species. The current situation is better as a result of important improvements in forest management in Iran and legal protection of the few fragmented stands left in Georgia. However, the species is facing a low regeneration rate and poor regeneration of natural forests.

### URGENT ACTIONS NEEDED

- > Implement a long-term monitoring programme for the species and its habitats to prevent a slow but gradual decline in the Alborz Mountains.
- > Strengthen the protection of the species in the Talysh Mountains.
- > Conduct supplementary field exploration to review historic localities, particularly for very isolated subpopulations in Turkey, in the Karabakh Mountains, Armenia and in western Iran.
- > Initiate a global *ex situ* conservation programme in the various countries of origin to preserve genetic diversity and the most vulnerable subpopulations.



1. *Zelkova carpinifolia* can produce many suckers at the foot of old trees. The Babaneuri Nature Reserve, Georgia (sb)

2. A typical landscape in the Babaneuri Nature Reserve where traditional agricultural practices are maintained and where one of the most important stands of *Zelkova carpinifolia* in Georgia is preserved. The Babaneuri Nature Reserve, Georgia (sb)



3. The original lowland and foothill forests of the Colchis region have almost entirely been destroyed. Currently, *Zelkova carpinifolia* is only distributed in a few locations across Georgia. The Sataplia Nature Reserve, Georgia (sb)

4. *Zelkova carpinifolia* is one of the most emblematic trees of the rich Hyrcanian forests in Azerbaijan. The Hyrcanian National Park, Azerbaijan (sb)



5. In Azerbaijan, open forests with a lack of juvenile trees are typical features due to the traditional practice of letting cattle roam and graze freely. The Hyrcanian National Park, Azerbaijan (sb)



# *Zelkova serrata* (Thun.) Makino

## Japanese Zelkova

Japan, China, North Korea, South Korea

Near Threatened

NT

B2b(ii)

Year of evaluation: 2018



### DISTRIBUTION

*Zelkova serrata* exhibits the largest geographic range of the genus with natural subpopulations present in Japan, China, North Korea and South Korea. Due to frequent misidentifications, the distribution of the species has probably been overestimated in China, and the presence in Fujian, Gansu, Hunan and Sichuan is uncertain. In Japan, the species is reported from the South of Kyushu Island (Kagoshima) to the North of Honshu Island (Aomori), with subpopulations present on Shikoku Island. The species is less common outside Japan, and mostly isolated subpopulations are known from the Korean Peninsula. The status of this tree in North Korea is unknown.

**E00** (extent of occurrence): 3,646,300 km<sup>2</sup>

**A00** (area of occupancy): > 900 km<sup>2</sup>

### NUMBER OF SUBPOPULATIONS

The total number of subpopulations is estimated to be around 300 mainly situated in Japan, but it is actually very complex to distinguish between native subpopulations and quite recent plantations. Of this total, approximately 30 subpopulations are present in China and in the Korean Peninsula.

### HABITAT

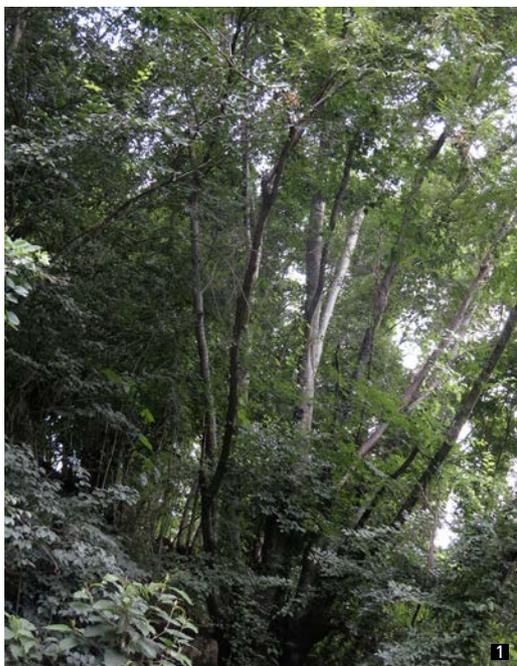
The species grows mainly in steep ravines and corridors along small rivers and streams between 500 and 2,000 m a.s.l. This tree experiences a variety of climates from temperate forests in northern Japan to montane mixed evergreen and deciduous broad-leaved forests in China. It has been extensively planted in Japan.

### THREATS

The main threats to *Z. serrata* are habitat loss due to rapid urbanization and agricultural expansion throughout the 20<sup>th</sup> century. Uncontrolled commercial logging is currently less common as a result of important plantations available for Asian markets throughout Japan. In China, populations of this species often exhibit a lack of young trees and seedlings, particularly in very isolated subpopulations that are made up of just a few mature individuals.

### URGENT ACTIONS NEEDED

- > Inventory and protection of the remaining natural subpopulations in Japan.
- > Prevent the loss of genetic diversity in *Zelkova* plantations in Japan using local material.
- > Initiate field explorations throughout China and North Korea.
- > Conserve the most vulnerable and fragmented subpopulations along the periphery of the main range of the species.
- > Enhance *ex situ* collections, particularly for small subpopulations in China and on the Korean Peninsula.



1

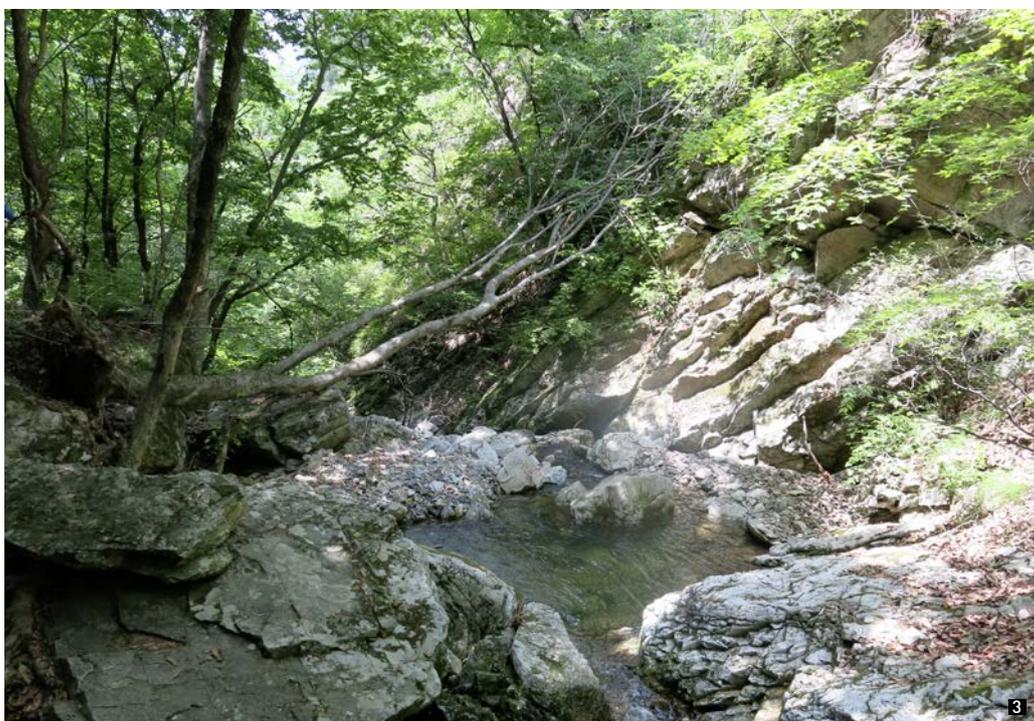


2

1. In China, stands of *Zelkova serrata* are generally composed of a few dozen individuals. The Jiuxiang Caves, Kunming, Yunnan Province, China (sb)

2. Despite its large distribution in China, ranging from the western Yunnan Province to the east coast (near the city of Qingdao), *Zelkova serrata* is only restricted to a few localities. The Lao Shan Mountains, Shandong Province, China (sb)

3. In the Korean Peninsula, natural stands of *Zelkova serrata* are very scattered and have been mainly preserved in the vicinities of temples and sacred sites. The Mungyeong Suejae Provincial Park, Chungcheongbuk-do Province, South Korea (sb)



3

4. A centennial tree of *Zelkova serrata* preserved in the Changdeokgung Palace; the species is still very important in the landscape architecture. Seoul, South Korea (sb)



4



5

5. Due to its large crown and its general beauty, *Zelkova serrata* is one of the most planted trees in the parks and streets of Japan and South Korea. The Changdeokgung Palace, Seoul, South Korea (sb)

# *Zelkova schneideriana* Hand.-Mazz.

## Schneider's Zelkova

China, Taiwan

Vulnerable   
A2c; C2a(i)  
Year of evaluation: 2018



### DISTRIBUTION

*Zelkova schneideriana* grows in various mountainous regions of mainland China with the exception of a few subpopulations on the island of Taiwan. In China, the species was historically present in 16 provinces: Anhui, Fujian, Gansu, Guangdong, Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Shanghai, Yunnan, and Zhejiang. The presence of the species in Xizang Province at 2,800 m a.s.l. is probably due to misidentification.

**E00** (extent of occurrence): 1,838,455 km<sup>2</sup>

**A00** (area of occupancy): 560 km<sup>2</sup>

### NUMBER OF SUBPOPULATIONS

An estimated total number of 3,000 to 5,000 mature individuals are distributed in approximately 100 subpopulations.

### HABITAT

The species grows mainly in ravines along streams and small rivers. It is an element of temperate to subtropical forest communities that are dominated by a variety of deciduous and evergreen species. The main elevational range of the species varies between 200 and 1,100 m a.s.l. with a maximum at 2,200 m a.s.l. in Yunnan.

### THREATS

Habitat loss represents the most significant threat to the species. Agricultural and urban expansion combined with the conversion of primary forests to plantation forests have severely impacted the species. However, since the 1980s, the protection of primary forests has increased in China with the creation of numerous protected areas and the implementation of more effective forest management. However, the situation for this species is still serious with the majority of localities containing only a dozen mature individuals with a low regeneration rate.

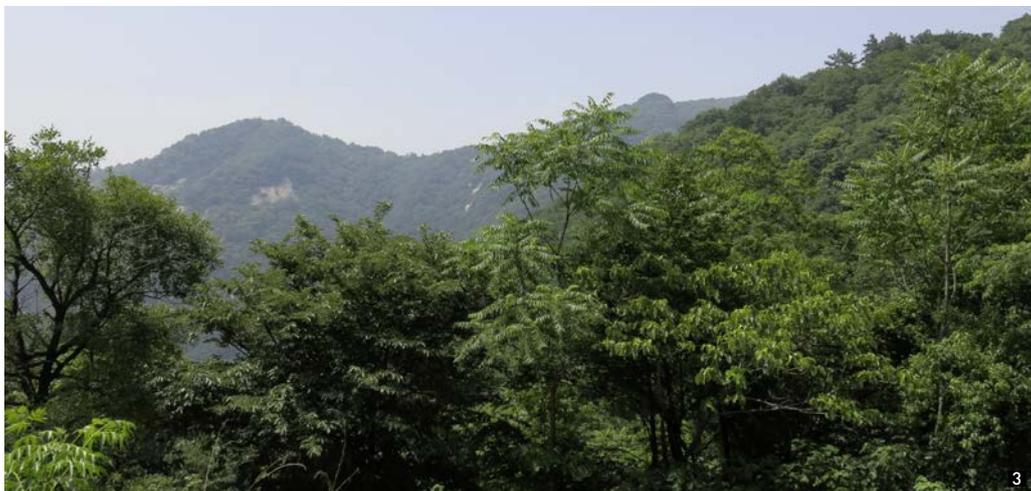
### URGENT ACTIONS NEEDED

- > Monitor a large selection of the remaining stands to detect any long term decrease in individuals.
- > Afforestation projects using local trees instead of standard forest plantations (e.g., bamboo, poplar, eucalyptus).
- > Field exploration to more accurately estimate the total number of individuals and current status of highly fragmented stands.
- > Enhance *ex situ* collections across the various regions of China, particularly for very small stands along the periphery of the main geographic range.



1. Very old individuals of this *Zelkova* species can sometimes be found in small villages of rural western China. The trees are considered sacred and are protected by local people and, more recently, by the Chinese government. Guizhou Province, China (sb)

2. Herbaria hold precious indications of the distribution of *Zelkova* species across China. However, misidentifications are easily made between the different species of *Zelkova*. The South China Botanical Garden, the Chinese Academy of Sciences, Guangzhou, China (sb)



3. *Zelkova schneideriana* can be used as an umbrella species in conservation of very rich and undisturbed forests in China. The Tongbai Mountain, Henan Province (sb)

4. *Zelkova schneideriana* is present near streams and rivers but can also form small stands in steep ravines with no water channels in the periphery. The Wuduo Mountain, Henan Province (sb)



5. Flooding can generate important damage to *Zelkova schneideriana* populations. Dabieshan Mountains, Anhui Province, China (sb)



6. Molecular methods showed that the populations from Taiwan belong to *Zelkova schneideriana* (and not to *Z. serrata*, as previously claimed). The Taroko National Park, Taiwan (ek)



# *Zelkova sinica* C. K. Schneid.

## Chinese Zelkova

China

Vulnerable   
A2c; C1  
Year of evaluation: 2018



### DISTRIBUTION

*Zelkova sinica* is an endemic tree from China mainly distributed across the mountainous regions of the centre of the country. Natural subpopulations are reported from the Provinces of Gansu, Hebei, Henan, Hubei, Shanxi, Shaanxi, and Sichuan and from the Chongqing Municipality. The main geographic range of the species includes the Qin Mountains (Qinling) with isolated subpopulations in adjacent mountain ranges.

**EOO** (extent of occurrence): 536,762 km<sup>2</sup>

**AOO** (area of occupancy): 256 km<sup>2</sup>

### NUMBER OF SUBPOPULATIONS

Around 4,000 mature individuals are distributed in approximately 50 subpopulations.

### HABITAT

The species typically grows in ravines and valleys along rivers. It is usually restricted to the vicinity of rivers, but can sometimes be found in drier habitats. The species is an element of the montane mixed evergreen and deciduous broad-leaved forests. The elevational range of the species is between 300 and 2,500 m a.s.l.

### THREATS

The main threats to *Z. sinica* are agricultural expansion and the conversion of primary forest to plantations. The loss of primary forest was particularly important from the 18<sup>th</sup> century to the 1980s. Uncontrolled commercial logging was very significant from the 1950s to the 1980s, and centennial trees were systematically cut for commercial trade. The regeneration of the species appears to be very weak, and the severe fragmentation of the species is also a major concern for the future.

### URGENT ACTIONS NEEDED

- > Monitor the remaining stands and ensure legal protection for the individuals or stands located outside the strict perimeter of protected areas.
- > Strengthen the protection of the species inside protected areas to avoid direct damage, for example, when creating new tourism infrastructure.
- > Create a sanctuary dedicated to *Z. sinica* in the only known important subpopulation (1,000 to 1,500 mature individuals) in Zhen Whu Ding (Nanzhao County, Henan Province).
- > Initiate an afforestation project using local proveniences.
- > Field exploration is necessary to check historic localities.
- > Enhance *ex situ* collections in China to conserve the genetic diversity of the species.



**1.** A large majority of *Zelkova sinica* stands are composed of only a dozen individuals. Zhen Whu Ding represents the only known important population with more than 1,000 individuals. Zhen Whu Ding, Henan Province, China (sb)

**2.** Clearcutting is still a common practice in the direct vicinity of protected areas in China. It would be important to create buffer zones with strict regulations (sustainable forestry and preventing the establishment of plantation). Zhen Whu Ding, Henan Province, China (sb)



**3.** The construction of a new road for touristic activities inside of a protected area has a direct negative impact on *Zelkova sinica* stands. Lao Jie Ling, Henan Province, China (sb)

**4.** The bark of *Zelkova sinica* is very attractive, making the species very popular for landscape architecture. The Baitong County, Henan Province, China (sb)



**5.** *Zelkova sinica* typically grows in the direct vicinity of streams and small rivers. The species is almost totally absent outside of protected areas. Quixin Tan, Henan Province, China (sb)

**6.** The strict protection of *Zelkova sinica* in Zhen Whu Ding would be the first step towards an effective protection of this emblematic tree of China. Zhen Whu Ding, Henan Province, China (sb)

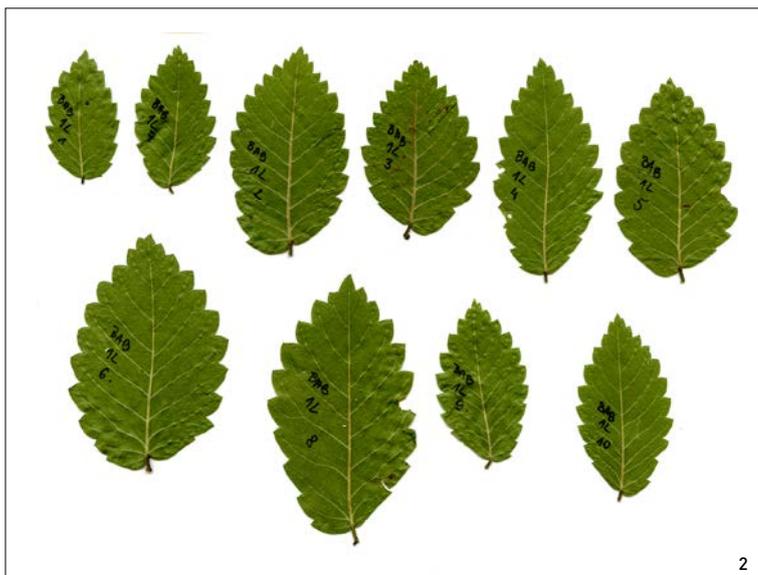
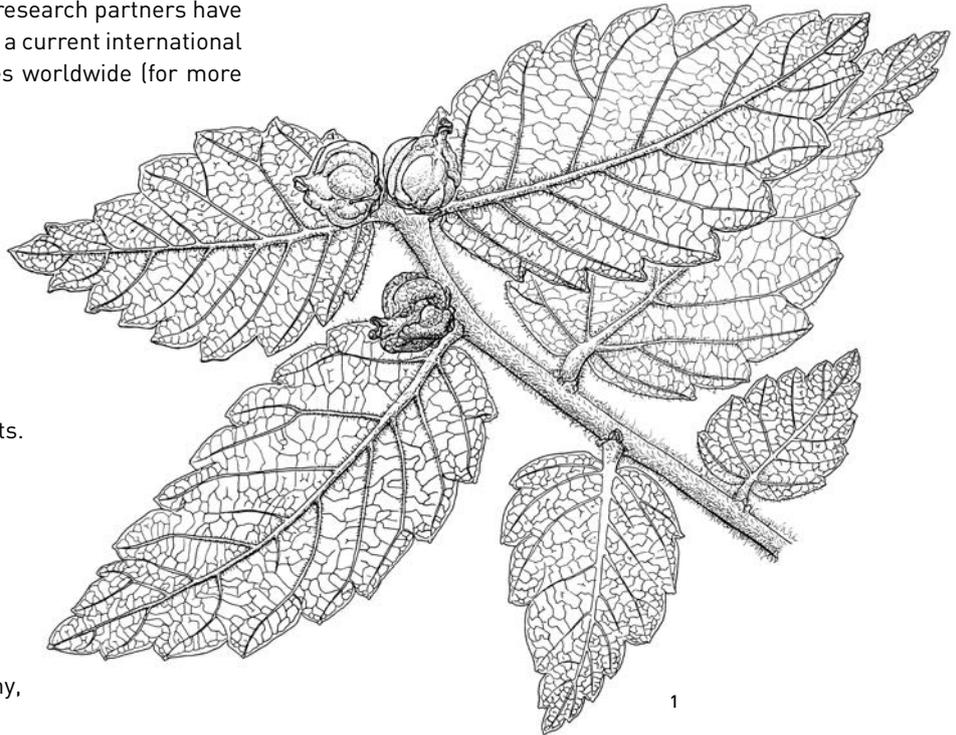


# Project *Zelkova*: a leading force in the research on and conservation of relict trees

In 2010, the Botanic Garden of the University of Fribourg (BGFR, Switzerland), in collaboration with the Natural History Museum Fribourg (NHMF, Switzerland) and Botanic Gardens Conservation International (BGCI, United Kingdom), initiated an interdisciplinary project to undertake the scientific review and coordinated conservation action on relict, rare and threatened woody species with a main focus on the relict tree genus *Zelkova* (Ulmaceae). Additional research partners have joined Project *Zelkova* during recent years to form a current international network of c. 20 institutions from c. 15 countries worldwide (for more details see [www.zelkova.ch](http://www.zelkova.ch)).

## PROJECT *ZELKOVA* ADDRESSES FIVE MAIN OBJECTIVES:

1. Basic and applied research on relict, rare and/or threatened woody species.
2. *In situ* and *ex situ* conservation activities, action plans and conservation status assessments.
3. Capacity-building (teaching, internships, exchange of students and young scientists, etc.).
4. Public awareness and outreach (exhibitions, books, workshops, etc.).
5. Iconographic collections (scientific photography, scientific drawings, etc.).



1. Enrichment of the iconographic collections is one of the objectives of *Zelkova* Project. A scientific drawing of *Zelkova carpinifolia* branches with fruits (ml)

2. Basic and applied research: morphometric analyses of *Zelkova carpinifolia* leaves carried out by the Institute of Dendrology of the Polish Academy of Sciences in Kórnik, Poland (akj)

During the last decade, Project *Zelkova* was the leading force in scientific exploration and conservation of the genus *Zelkova* and more generally of relict and threatened woody species worldwide. One of the first achievements of the project was the global survey of the *ex situ* conservation of all six *Zelkova* species (Kozłowski et al. 2012a) as well as a monograph of the genus *Zelkova* (Kozłowski & Gratzfeld 2013) describing its global status and the conservation measures needed for long term conservation of these emblematic trees. This work was conducted in collaboration with Botanic Gardens Conservation International (BGCI, United Kingdom).

Even at this early stage of the project, one of the main priorities was the Cretan endemic *Z. abelicea*. In collaboration with the University of Crete (Greece) and the University of Bern (Switzerland), some breakthroughs in understanding the ecology and conservation needs of *Z. abelicea* were made (Fazan et al. 2012, Kozłowski et al. 2012b, Kozłowski et al. 2014, Bosque et al. 2014). One of the highlights of this period was the discovery by Laurence Fazan that small, heavily browsed *Z. abelicea* individuals can attain a very old age (> 600 years). In addition, recently published important dendrochronological work (Fazan et al. 2017) examined how *Z. abelicea* copes with the Mediterranean climate, and demonstrated that this relict species is able to withstand changing environmental conditions.

In collaboration with the Institute of Dendrology of the Polish Academy of Sciences in Kórnik, a series of morphometric investigations of leaves of the Transcaucasian *Z. carpinifolia* were conducted (Jasińska et al. 2015). The most recent publication explores the utility of morphological characters of the three western Eurasian taxa (*Z. carpinifolia*, *Z. abelicea* and *Z. sicula*) for the identification of fossil material (Jasińska et al. 2018).

Simultaneously, the three western Eurasian *Zelkova* species were also studied using molecular methods. This work was done in collaboration with the Conservatoire et Jardin botaniques de la Ville de Genève (Switzerland) as well as the Botanic Garden and Botanic Museum in Berlin (Germany). Christe et al. (2014a) elucidated the phylogeographic patterns of the three western Eurasian taxa showing, for example, that *Z. abelicea* possesses an extremely high genetic diversity within its natural populations on Crete and that *Z. sicula* might have a hybrid origin. However, Christe et al. (2014b) demonstrated that the *ex situ* collections of *Z. abelicea* in botanic gardens do not represent the high genetic diversity of the species. This work highlighted the need for re-evaluating the existing living *ex situ* collections of trees and the development of new strategies for future conservation efforts in botanic gardens and arboreta.

All of the morphometric and genetic investigations of *Z. carpinifolia* and the explorations of the Transcaucasian region highlighted above profited from an excellent collaboration with numerous research institutes from Turkey, Iran, Azerbaijan and Georgia, particularly with the Institute of Botany of the Azerbaijan National Academy of Sciences in Baku, the Hyrcanian National Park (Azerbaijan), and the National Botanic Garden of Georgia (Tbilisi). The undisputable highlight of the exploration of the Hyrcanian and Colchic regions in Transcaucasia were two exhibitions prepared by the *Zelkova* team from Fribourg and displayed at the Botany Museum of the Institute of Botany in Baku, Azerbaijan (2014) and at the Natural History Museum Fribourg in Switzerland (2015).



1. The exhibition *De mémoire d'arbre / Bäume erinnern sich* (2015) on the diversity, biogeography and conservation of relict trees at the Natural History Museum Fribourg (Switzerland) was one of the main achievements of the *Zelkova* Project [gt]



Today, Project *Zelkova* continues the research and conservation work on *Z. abelicea* on Crete. The main local partners are the Mediterranean Agronomic Institute of Chania and all four Forest Directorates of Crete (Chania, Rethymno, Heraklion and Lassithi). The local project entitled “Conservation of *Zelkova abelicea* in Crete” was launched in 2014. The overall objective of this project is to promote and enable the long term conservation of the natural populations of *Z. abelicea* in Crete through i) *in situ* conservation actions such as fencing selected plots, ii) *ex situ* conservation actions such as *ex situ* plantations and iii) public awareness and dissemination actions to promote and advertise the value of *Z. abelicea* to the general public and to influence decisions-makers. The first phase of the project (2014-2016) was successfully implemented, and the project is currently in its second phase (2017-2020). Additional information is available at [www.abelitsia.gr](http://www.abelitsia.gr).

The research and conservation actions involving *Z. sicula* on Sicily are underway as well (Garfi et al. 2017a, b, c). This work is conducted by Dr. Giuseppe Garfi from the Institute of Biosciences and BioResources of the National Research Council from Palermo (Sicily, Italy), who discovered the species in 1991. The *Zelkova* team of the University of Fribourg (Switzerland) is actively participating in the development of new and efficient propagation techniques using tissue culture methods. The main highlight of recent years, however, is the assisted colonisation of *Z. sicula* into new sites in northern Sicily. Additional information is available at [www.zelkovazione.eu](http://www.zelkovazione.eu).

Exploration of the East Asiatic *Zelkova* species is also underway. The most recent work is a molecular study by Naciri et al. (2018) that demonstrates, for the first time, the phylogenetic relationships and phylogeographic patterns of *Z. serrata*, *Z. schneideriana* and *Z. sinica* using samples collected from natural populations across the entire range of the genus. This work was conducted by the Conservatoire et Jardin botaniques de la Ville de Genève (Switzerland) in collaboration with the University of Fribourg (Switzerland), the Shanghai Chenshan Plant Science Research Centre of the Chinese Academy of Sciences (China) and the Nanyang Normal University (China).

Finally, “The Red List of *Zelkova*” would not be possible without the revision of the conservation status assessment for *Z. carpinifolia* (Bétrisey et al. 2018a) as well as the first-ever assessments of the three East Asiatic species, *Z. serrata*, *Z. schneideriana* and *Z. sinica* (Bétrisey et al. 2018b, c; Song et al. 2018). These assessments as well as the present compilation crown the laborious but significant legacy of the Project *Zelkova*.





1. Students of the University of Fribourg (Switzerland) visiting populations of *Zelkova sicula* in Sicily, Italy (gk)

2. An international workshop on the conservation of relict trees in the Kolkheti National Park (Georgia) (akj)

3. An international symposium at the National Botanic Garden of Georgia in Tbilisi (sb)

4. A field excursion in the Wielkopolski National Park, Poland (gk)

5. Laurence Fazan exploring *Zelkova abelicea* in Crete, Greece (mc)

6. Monitoring of vegetation in a study plot of *Zelkova abelicea* in Crete, Greece (cm)

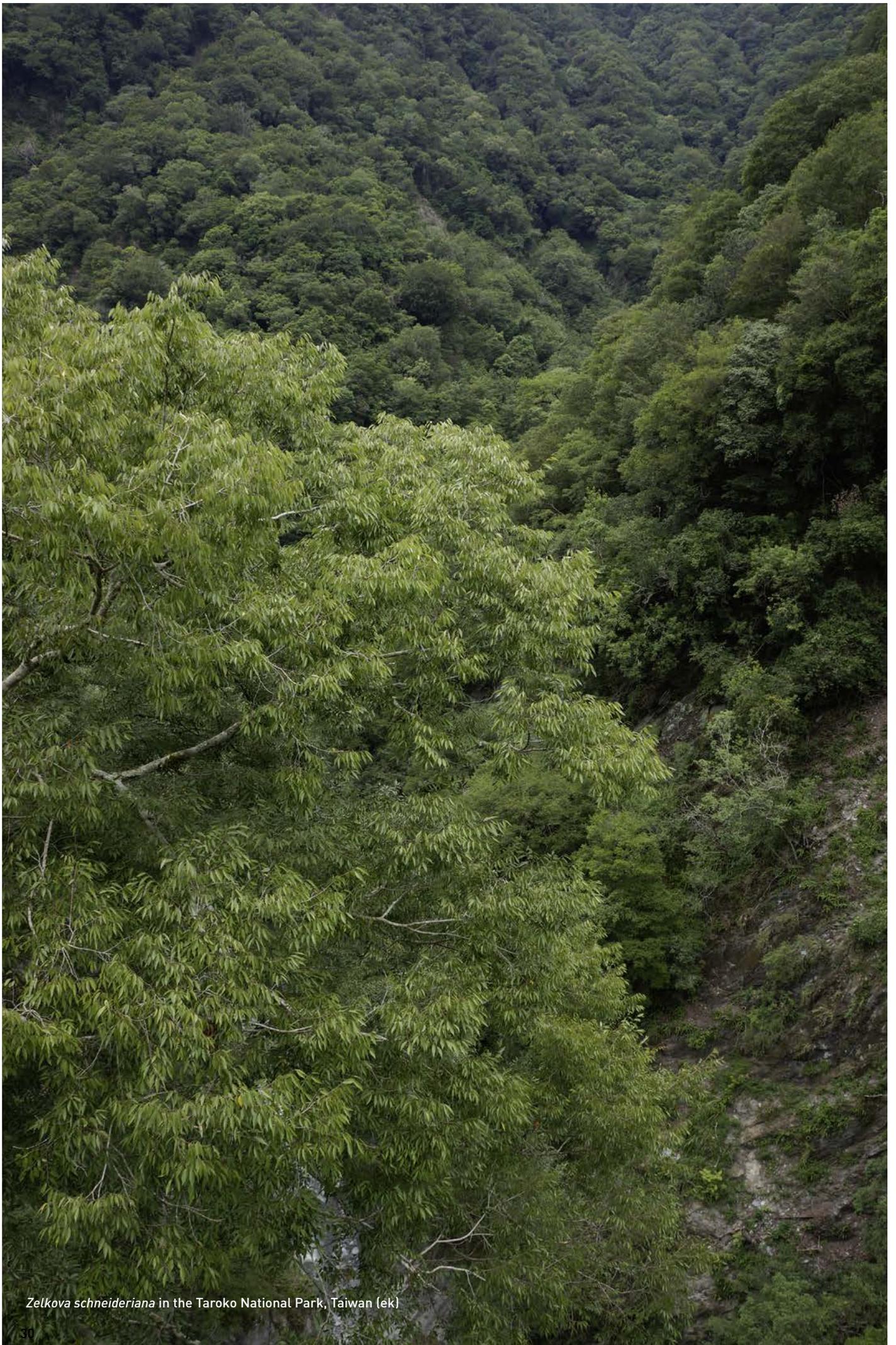
7. Sebastien Bétrisey studying the East Asiatic *Zelkova* species (sb)

8. Yi-Gang Song sampling *Zelkova* species in China (ygs)

9. Yann Fragnière at the Botanic Garden of the University of Fribourg (gm)

10. Dispersal units (branches with fruits) of *Zelkova abelicea* (ek)





*Zelkova schneideriana* in the Taroko National Park, Taiwan (ek)

## ACKNOWLEDGEMENTS

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