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An insight into the most threatened flora of China

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Abstract

China harbors a very rich plant biodiversity both in total number of taxa and in endemism. Nevertheless, a significant fraction of this diversity (up to 20% of the native plants to China) is currently threatened. Among this endangered flora, an appreciable but still unquantified number of taxa are in an extreme situation of risk because of their low population sizes, often consisting of fewer than 100 individuals. We have selected 20 plant taxa as a sample of this extremely threatened flora, and, from these, information about their geographic range, population size, threats, existing conservation measures, legal status and threat degree (according to the IUCN criteria) is provided. The extreme rarity of these taxa can be linked to their evolutionary history (they are palaeo- or neoendemics) and/or to severe human disturbance (mostly habitat destruction and overexploitation) affecting them.

Key words: conservation; endangered; endemic; plant species; rare.

Resumen

Una aproximación al conocimiento de la flora más amenazada de China.- China posee una gran diversidad de especies vegetales, tanto en lo que se refiere al número total de taxones como a la cantidad de endemismos. Sin embargo, una parte significativa de esta diversidad (hasta un 20% de la flora autóctona) está amenazada en algún grado. Una cantidad apreciable aunque todavía indeterminada de taxones se encuentra en una situación de extremo riesgo debido a su escaso número de efectivos, a menudo inferior al centenar. Se han seleccionado 20 taxones como muestra representativa de esta flora en situación muy crítica, de los que se proporciona información sobre su área de distribución, tamaño poblacional, amenazas, medidas de conservación adoptadas, estatus legal y categoría de amenaza (de acuerdo con los criterios de la UICN). La rareza extrema de estos taxones puede relacionarse con su historia evolutiva (por su condición de paleo- o neoendemismos) y/o con la actuación humana (principalmente destrucción de hábitats y sobreexplotación).

Palabras clave: amenazada; conservación; endemismo; especies vegetales; rara.

CHINESE FLORA: VERY DIVERSE BUT ENDANGERED

China is one of the richest countries of the world in terms of plant biodiversity, with more than 30,000 vascular plant taxa, and a very high endemism rate which might surpass 50% (SEPA, 1998; López-Pujol *et al.*, 2006; CSPCEC, 2008). A growing fraction of this diversity is, unfortunately, threatened by extinction, and some authors have reported a number of endangered species ranging from 3,000 to 5,000, i.e. up to 20% of the total flora (Wang, 1992; Gu, 1998; Zhang, 2007; CSPCEC, 2008). However, and according to more recent studies (Wang & Xie, 2004; Xie & Wang, 2007), this figure could be even higher. For instance, from the ca. 4,200 angiosperm taxa (i.e. just 14% of the total number of angiosperms in China) assessed in the first phase of the elaboration of the *China Species Red List* (Wang & Xie, 2004; Xie & Wang, 2007), over 3,600 (87%) were regarded as threatened following the 2001 IUCN criteria (CR, EN, or VU), and up to 651 were assigned to the CR (Critically Endangered) category, that is, facing an imminent risk of extinction.

These large-scale evaluations of the Chinese flora, in addition to other studies (Gu, 2003; Cicuzza *et al.*, 2007; Olfield & Eastwood, 2007), have pinpointed the existence of an appreciable, but still unquantified, number of Chinese plants in an extreme situation of risk, taxa typically with one or very few (2-3) localities and total population sizes consisting of a few dozens of individuals or even fewer. In fact, China probably harbors the most rare and endangered conifers in the world (e.g. *Cupressus chengiana* var. *jiangeensis* and *Abies beshanzenensis* var. *beshanzenensis*, from which only one and three individuals are remaining, respectively; see Appendix 1), but also angiosperms (e.g. *Carpinus putoensis*, *Gleditsia japonica* var. *velutina*, and *Acer yangbiense*, with just one, two and four individuals remaining in the wild, respectively; see also Appendix 1). Unless effective conservation measures are taken, these very rare and endangered taxa are condemned to disappear from nature in the near future.

Extinction seems to have occurred for several plant species whose status in the wild was reported as very endangered just a few years ago, such as *Betula halophila* or *Cystoathyrium chinense* (Zhang & Ma, 2008). In addition, other more common taxa have suffered a process of fast rarification in recent

years and today qualify as CR under criterion D (less than 50 individuals remaining in the wild). For example, *Picea neoveitchii* was “only” classified as VU (Vulnerable) in the *China Species Red List* (Wang & Xie, 2004) which was compiled during the period 2000-2003; currently, this species may have less than 20 individuals remaining, and should be undoubtedly included within the CR category (Zhang, 2007).

A SELECTION OF THE MOST ENDANGERED CHINESE FLORA

Based on the current knowledge, we have elaborated a list of 20 plant taxa as a sample of the extremely endangered flora of China (Appendix 1). Being aware of the still relatively poor taxonomic and chorological knowledge of the Chinese flora, the taxa presented here do not represent in any case a complete, “closed” list of the most threatened plants, which is beyond the scope of this paper. Instead, we are aimed to reflect the very critical situation of a growing number of plant taxa in China, which may soon disappear from the wild.

Only those plant taxa with an agreed taxonomy have been selected, and the main groups of vascular plants (ferns, gymnosperms and angiosperms) are all represented. In addition to taxa facing an extremely high risk of extinction in the wild (those classified as CR), examples of species recently extinct in the wild (EW) have also been included. Information about their geographic range (Appendix 2), population size (total number of individuals of the taxon), ecology, threats, and existing conservation measures have been gathered for all the 20 taxa. In addition, their vernacular names, both in *jianhuazi* (simplified Chinese characters) and *pinyin* (romanization system for Chinese), the synonymy, and a brief description of the plant have also been included. Finally, their legal status and threat degree (according to the IUCN categories) are also provided (Appendix 3).

ENDEMISM VS. HUMAN THREATS AS CAUSES OF ENDANGERMENT

The occurrence of many such cases of extremely rare and endangered plants in China, well exemplified by the 20 taxa selected here (Appendix 1), can be explained by both natural and human-induced

factors, in many cases acting synergistically. Most of these plant taxa were probably already rare well before the human activities began to seriously impact the Chinese natural ecosystems (i.e. “naturally rare” plant taxa). In this case, the evolutionary history of plant species can explain, at least in part, their current extremely scarce distribution. Compared to other regions in the world, China is plenty of relict lineages (e.g. Qian & Ricklefs, 1999; Qian, 2001), which had a widespread distribution in the past but that the late Tertiary and Quaternary climatic deterioration caused their local extinction from many areas and their confinement to favorable enclaves (the so-called “glacial refugia”), surviving in small and isolated populations. Although not so well known as *Cathaya*, *Ginkgo*, *Glyptostrobus* or *Metasequoia*, most of the taxa contained in Appendix 1 are likely paleoendemics which have suffered severe contractions of their former distribution areas.

Pleistocene glacial refugia, in addition to be suitable areas for the persistence of ancient lineages during the Quaternary, also served as centres of plant evolution and diversification (Tzedakis *et al.*, 2002). Thus, the rarity of some plants should be explained, instead, by the lack of enough time to spread from their centres of origin (i.e. neoendemisms). From Appendix 1, this can be the case of *Sinojackia sarcocarpa*, a currently speciating taxon according to Yao *et al.* (2008). Notoriously, all the 20 plant taxa compiled here are exclusively located in central and southern China (see Appendix 2), where the existence of numerous and extensive Quaternary plant glacial refugia has been hypothesized (e.g. Ying *et al.*, 1993; Wang & Liu, 1994; López-Pujol, 2008).

The large-scale human-mediated modification of the environment in China, especially intensified from the 1950s, has undoubtedly put a lot of pressure on plant biodiversity (e.g. Liu *et al.*, 2003; López-Pujol *et al.*, 2006). Obviously, the impact has been more severe on the plants which were already rare, pushing them to the brink of extinction or even producing their extirpation from nature. In fact, it is thought that at least 200 plant taxa have become extinct from the 1950s (Zhang *et al.*, 2000), most likely due to habitat destruction, fragmentation or deterioration. To our knowledge, dam building (an extreme case of habitat destruction) has caused the extinction of at least two plant species in China because their populations were

located in the areas to be flooded: *Rhododendron kanehirai*, in Taiwan Island (IUCN, 2008), and *Plantago fengdouensis* (Appendix 1), in the Three Gorges Reservoir Region.

The critical situation for most of the plant taxa included in Appendix 1 is probably also a consequence of the destruction of natural ecosystems, sometimes combined with the overexploitation of these species. For example, habitat destruction is the main reason for the extirpation of *Euryodendron excelsum* from Guangxi Province (Appendix 1 and Fig. 1), which is at present surviving only in a small population in Yangchun County, in Guangdong (Shen *et al.*, 2008). *Picea neveitchii*, a taxon formerly present in up to 6 provinces according to *Flora of China*, has reached its current highly threatened status (only 11 mature individuals are remaining; Appendix 1) mainly as a consequence of the combination of overexploitation (due to its use as timber) and habitat fragmentation (Zhang, 2007). The massive collection of individuals because of their ornamental value has contributed to the fact that most of the *Cycas* species of China, including that present in Appendix 1, are today endangered (Donaldson, 2003).

Pollution has also contributed to the endangerment of rare species in China: the contamination and eutrophication of the aquatic habitats where the four *Isoetes* species native to China are living are among the main causes for the decline and loss of populations (Liu *et al.*, 2005). For example, *Isoetes yunguiensis* (which is included in Appendix 1) has lost most of their former distribution area (it has been completely extirpated from Yunnan), and the only remaining population in Guizhou (with only about 50 individuals) is severely menaced by pollution and overgrazing (Liu *et al.*, 2005; Chen *et al.*, 2007).

In addition to human threats, stochastic events (such as a natural catastrophe) can cause the direct extirpation of these species from nature due to their extremely reduced number of populations and individuals (well below the minimum viable population size, MVP). For example, with Taiwan's 1999 earthquake, the unique population of *Isoetes taiwanensis* shrank from 5,000 to only 50 individuals, and its occupation area also diminished from 2,000 to <10 m² (Liu *et al.*, 2005). Finally, the progression of climate change (global warming) may represent the *coup de grâce* for these extremely rare and endangered species.

CONSERVATION OF THE CHINESE EXTREMELY THREATENED FLORA

Although in China the conservation of nature can be traced back many centuries and even millenia, the “modern” conservation practices started late (mainly since the middle twentieth century), and were almost totally suspended during the convulse years of the Cultural Revolution (1966-1976). However, from the late 1970s, and coinciding with the onset of the economic reforms, they received a new and definitive impulse, including those related to the rare and endangered flora (Gu, 1998; Xu *et al.*, 1999; López-Pujol *et al.*, 2006; Zhang, 2007). Regarding in-situ plant conservation, China has experienced an astonishing expansion of its network of protected areas in recent years, now covering more than 15% of the total land area. China has also implemented several ex-situ measures to protect its flora, such as the building of numerous botanical gardens and arboreta (ca. 160), but also field nurseries and plant introduction bases, which are assuring the conservation of more than half of the plants native to China (CSPCEC, 2008). In addition, field work oriented to expand the chorological knowledge of the Chinese flora has experienced a great advance in recent years. For example, the populations of *Apterosperma oblata* discovered in recent years have increased the total population size of this endangered species from just a few individuals to more than one thousand (Yuan *et al.*, 2007).

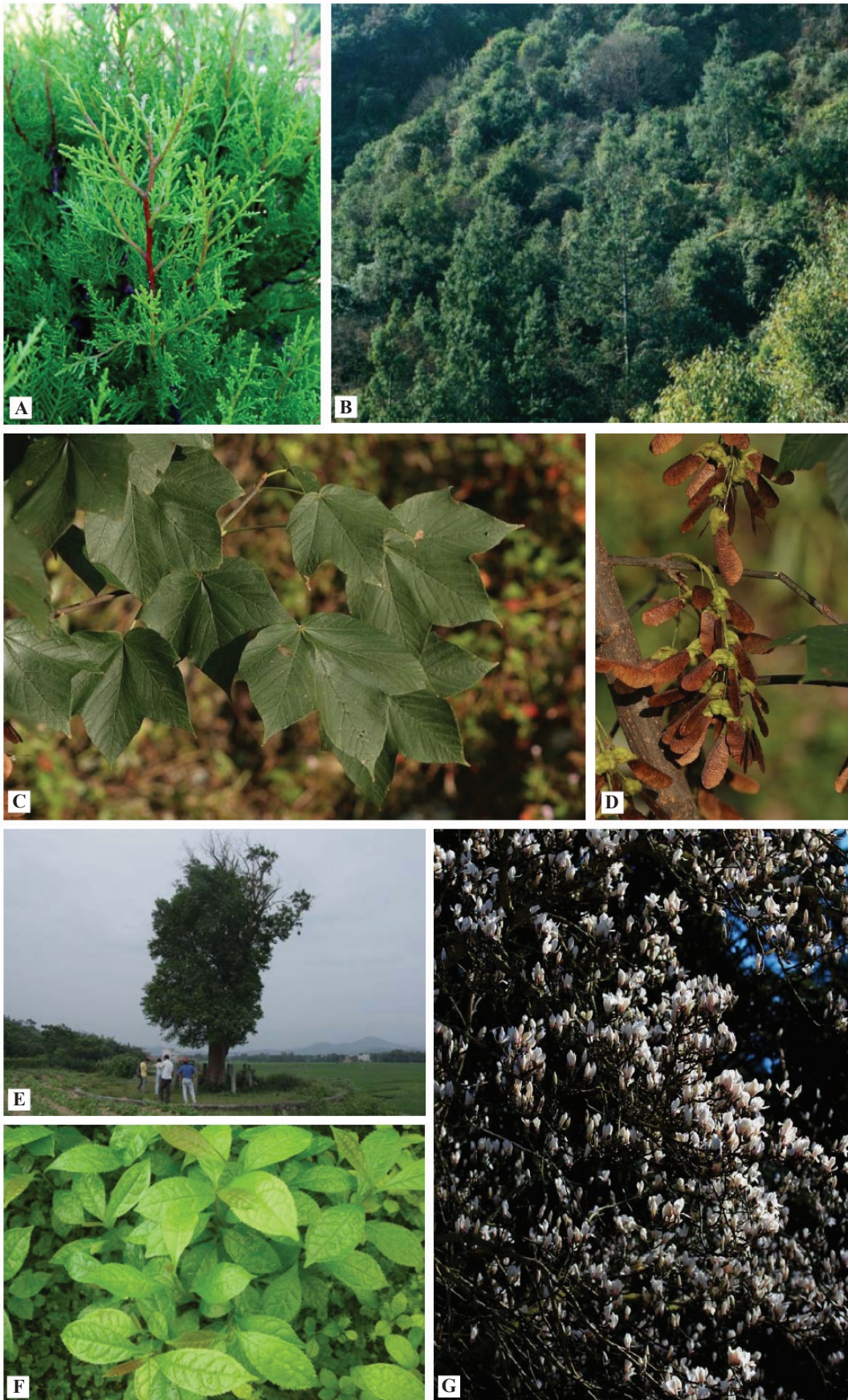
It should be noted that a significant fraction of the 20 extremely endangered plant taxa presented here are either included (partially or totally) within a protected area or cultivated (or their seeds preserved) in a botanical garden (see Appendix 1). It must be equally noted, however, that nature reserves in China are not always properly managed (mainly due to lack of funds and staff), and that both the sizes of the

collections and the number of gardens where a given plant is cultivated are generally insufficient (Xu, 1997; Zhang, 2007). For example, the only ex-situ collection of *Picea neveitchii* consist of two individuals cultivated in the Xi’an Botanical Garden (Zhang, 2007).

In addition to in-situ and ex-situ conservation measures, a lot of environmental legislation has been promulgated in the last two decades in China (as restrictive as European in many aspects but with many problems related to its enforcement still remaining), including some protection lists for rare and endangered species: the *National List of Rare and Endangered Plant Species* (issued in 1984), from which the *China Plant Red Data Book* (Fu, 1992) was later released, and the first batch of the *Catalogue of the National Protected Key Wild Plants* (1999) under the *Regulations on Protection of Wild Plants* (1997), which contained about 300 strictly protected plant taxa (Zhang & Ma, 2008). Despite the extremely endangered flora of China (exemplified by the taxa included in Appendix 1) is mostly included in these protection lists (Appendix 3), some of the theoretically protected taxa still lack of effective conservation measures, and even a few seem to have disappeared from the wild, such as *Cystoathyrium chinense*, *Betula halophila*, or *Betula jinpingensis* (Zhang & Ma, 2008).

Fortunately, most of these deficiencies in plant conservation are in the way to be corrected. The recently launched *China’s National Strategy for Plant Conservation* will mean a great improvement both in the in-situ and ex-situ conservation of plant species (CSPCEC, 2008). Moreover, the implementation of comprehensive conservation and/or restoration programs for endangered plants has also taken root in China during the last few years: these have allowed, for example, the effective protection of the populations of *Myricaria laxiflora* and *Adiantum reniforme* var. *sinense* to be flooded by the Three Gorges Reservoir (through

Figure 1. Some of the most threatened plant taxa of China: (A), Cultivated individual of *Cupressus chengiana* var. *jiangensis* in Mendocino Coast Botanical Garden (California, USA) [Picture: Chris Woods]; (B), Several individuals of *Pinus squamata* in its natural habitat [Picture: Zhi-Yong Zhang]; (C) and (D), Leaves and fruits of a wild individual of *Acer yangbiense* [Pictures: Yousheng Chen]; (E) and (F), wild individual of *Euryodendron excelsum*, and greenhouse cultivated ones [Pictures: Shen Shikang]; (G), Cultivated individual of *Magnolia zenii* in University of British Columbia Botanical Garden (British Columbia, Canada) [Picture: Daniel Mosquin].



ex-situ cultivation and further translocation to the field; Kang *et al.*, 2006; Liu *et al.*, 2006). For some of the taxa included in Appendix 1 (and even for plants not still legally protected, e.g. *Acer yangbiense*) conservation measures beyond mere inclusion in nature reserves or cultivation in botanical gardens are underway or projected, in order to assure their long-term viability. For example, a reinforcement program for *Pachylarnax sinica* (= *Manglietiastrum sinicum*), a Magnoliaceae with only about 50 individuals remaining in the wild, has completed its first stage with a notable success: about 200 saplings (coming from local nurseries which have produced over 5,000 young trees) were introduced in 2007 in its population of Xiaoqiaogou Nature Reserve, with survival rates of ca. 90% (GTC, 2008). A restoration program has also been planned for *Acer yangbiense* (Fig. 1) in order to increase its current population size (only 4 individuals; BGCI, 2008a). In other cases, urgent and drastic measures have had to be taken in order to save plant species from their imminent extinction, e.g. *Plantago fengdouensis*. All the living individuals of this species endemic to the Three Gorges Reservoir Region were transplanted to a botanical garden before the flooding of its natural populations (People's Daily, 2008).

The accumulated experience from these ongoing or already completed conservation and restoration programs should be applied to those threatened species still lacking effective preservation measures, in order to prevent further decline. To our knowledge, insufficient or no in-situ and ex-situ conservation measures have been implemented for several plant taxa from Appendix 1 (for example, up to eight taxa appear not to be cultivated in botanical gardens), a fact which may be behind their rarefaction or even their putative extinction (e.g. *Craigia kwangsiensis*). It is also highly advisable that the forthcoming protected plant lists include the obligation to develop and implement management and/or recovery programs (for at least the most endangered taxa, as occurs in some countries such as the United States). These programs, in addition to comprise "classical" tools (e.g. establishment of plant reserves, population monitoring, seed collection, education and outreach), should also include the most novel approaches in conservation biology, such as DNA banking (Dulloo *et al.*, 2006).

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Appendix 1. A selection of 20 of the most threatened plant taxa of China.

PTERIDOPHYTA

[1] *Cystoathyrium chinense* Ching (Athuriaceae)

Synonym(s): —

Vernacular name(s): *guang ye jue* (光叶蕨).

Brief description: Perennial herb, fronds 40-45 cm tall.

Geographic range and ecology: Tuanniuping, Erlang Mountain, Tianquan County (W Sichuan), 2450 m. Damp areas under forests.

Population size: In 1984 only one individual was remaining. Now it is probably extinct.

Threats: Habitat destruction (deforestation).

Conservation measures: Erlang Mountain is a national forest park; ex-situ conservation measures are unknown; taxon protected by law (see Appendix 3).

Sources of information: IUCN (2008); Zhang & Ma (2008); Zhang X.-C. (pers. comm.).

[2] *Isoetes yunguiensis* Q.F. Wang & W.C. Taylor (Isoetaceae)

Synonym(s): —

Vernacular name(s): *yun gui shui jiu* (云贵水韭).

Brief description: Aquatic perennial herb, leaves 10-50 cm long.

Geographic range and ecology: Shashi Valley, Pingba County (W Guizhou), 1280 m. Valley swamp.

Population size: About 50 individuals remain. Three other localities have become extinct in recent years (two in Yunnan and one in Guizhou), and the extant locality is declining.

Threats: Habitat destruction (urbanization); water pollution and eutrophication; overgrazing; interspecific competition.

Conservation measures: In-situ conservation measures are unknown; artificial propagation has been carried out; taxon protected by law (see Appendix 3).

Sources of information: Wang *et al.* (2002); Liu *et al.* (2005); Chen *et al.* (2007).

GYMNOSPERMAE

[3] *Abies beshanzenensis* M.H. Wu var. *beshanzenensis* (Pinaceae)

Synonym(s): *Abies fabri* (Mast.) Craib var. *beshanzenensis* (M.H. Wu) Silba

Vernacular name(s): *bai shan zu leng shan* (百山祖冷杉).

Brief description: Evergreen tree, up to 30 m tall and to 60 cm dbh.

Geographic range and ecology: Baishanzu Mountain, Qingyuan County (SW Zhejiang), at about 1700 m. Mixed forests with broad-leaved trees.

Population size: Only three individuals.

Threats: Expansive agriculture; fires; storms or typhoons; lack of regeneration (no viable seeds are produced, cones rarely appear); low genetic diversity.

Conservation measures: The extant locality is protected by a nature reserve; successfully grafted on *Abies firma*; replanted in its original locality and in nearby sites; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: Farjon (1990); Ai *et al.* (2005); Debreczy & Rácz (2008); IUCN (2008).

[4] *Cupressus chengiana* S.Y. Hu var. *jiangeensis* (N. Zhao) Silba (Cupressaceae)

Synonym(s): *Cupressus jiangeensis* N. Zhao

Vernacular name(s): *jian ge bai mu* (剑阁柏木).

Brief description: Evergreen tree, up to 30 m tall and to 100 cm dbh (Fig. 1).

Geographic range and ecology: Jiange County, Longmen Mountains (N Sichuan), 2800 m. Mixed coniferous-deciduous forests.

Population size: Only one wild individual is known.

Threats: Other threats apart from the small population size are unknown.

Conservation measures: The individual is protected in Jianmen Shudao National Park; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: Wang & Xie (2004); IUCN (2008).

Appendix 1. (Cont.)

[5] *Cycas hongheensis* S.Y. Yang & S.L. Yang ex D. Yue Wang (Cycadaceae)

Synonym(s): —

Vernacular name(s): *hui gan su tie* (灰干苏铁).

Brief description: Arborescent stems 1-3 m tall, 12-25 leaves in crown.

Geographic range and ecology: Hong He River valley, Gejiu City (SE Yunnan), 400-600 m. Open forests on limestone.

Population size: About 100 individuals.

Threats: Overexploitation (ornamental use); habitat destruction.

Conservation measures: In-situ conservation measures are unknown; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: Donaldson (2003); Hill (2008).

[6] *Picea neveitchii* Mast. (Pinaceae)

Synonym(s): —

Vernacular name(s): *da guo qing qian* (大果青杉).

Brief description: Evergreen tree, up to 15 m tall and to 50 cm dbh.

Geographic range and ecology: Distributed in four distinct localities along Qinling Mountain Range: Baotianman Nature Reserve (Neixiang County, W Henan), Taibai and Xinjiashan Forest Farms (Baoji Prefecture, SW Shaanxi), and Bailongjiang Forest Farm (Zhouqu County, SE Gansu)*, 1200-2000 m. Montane coniferous forests.

Population size: The 4 populations altogether contain only 13 individuals (11 mature ones and 2 seedlings)*.

Threats: Habitat destruction; overexploitation (use as timber); interspecific competition.

Conservation measures: Partially protected by nature reserves; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: Zhang (2007); IUCN (2008); Zhang D. (pers. comm.).

[7] *Pinus squamata* X.W. Li (Pinaceae)

Synonym(s): —

Vernacular name(s): *qiao jia wu zhen song* (巧家五针松).

Brief description: Evergreen tree to 20 m tall; trunk to 50 cm dbh (or more, because no old trees are known) (Fig. 1).

Geographic range and ecology: Yangjiawan and Fushan, Qiaojia County (NE Yunnan), 1900 m. Moist montane forests.

Population size: 1 locality (two subpopulations) totaling 32 individuals.

Threats: Habitat destruction (farming and logging); overexploitation (use as timber or firewood); low genetic diversity.

Conservation measures: A specific reserve for this species has been set up; artificial propagation has been carried out; taxon protected by law (see Appendix 3).

Sources of information: Zhang *et al.* (2005); Debreczy & Rácz (2008).

* According to several sources, including *Flora of China*, the species is rare but scattered along several provinces in central and northern China. The monographic study of Zhang (2007) reports, however, a much smaller range (currently restricted to the only four abovementioned localities), due to taxonomic confusion and to the fact that the species has suffered a severe decline in recent years (mainly caused by overexploitation and habitat destruction).

Appendix 1. (Cont.)

ANGIOSPERMAE

[8] *Acer yangbiense* Y.S. Chen & Q.E. Yang (Sapindaceae)**Synonym(s):** —**Vernacular name(s):** *yang bi feng* (漾鼻枫).**Brief description:** Deciduous tree, up to 20 m tall and to 20 cm dbh (Fig. 1).**Geographic range and ecology:** Cang Mountain, Yangbi County (W Yunnan), 2400 m. Mixed forests.**Population size:** Only 4 individuals.**Threats:** Habitat destruction (urbanization); overexploitation (use as fuelwood), poor regeneration.**Conservation measures:** Two individuals are included within a nature reserve; no ex-situ conservation measures have been implemented (but previous studies aimed to propagate it are under way, and the species will be cultivated in Kunming Botanical Garden).**Sources of information:** Chen *et al.* (2003); BGCI (2008*a,b*); Chen Y. (pers. comm.).**[9] *Carpinus putoensis* W.C. Cheng (Betulaceae)****Synonym(s):** —**Vernacular name(s):** *pu tuo e er li* (普陀鹅耳枥).**Brief description:** Deciduous tree, up to 15 m tall and to 70 cm dbh.**Geographic range and ecology:** Foding Mountain, Putuoshan Island, Zhoushan Archipelago (E Zhejiang), 240 m. Subtropical broad-leaved forests.**Population size:** Only one wild individual known.**Threats:** Habitat loss; no regeneration; storms or typhoons.**Conservation measures:** The unique individual is fenced, and located within a national park; cultivated in botanical gardens; artificial propagation has been carried out; taxon protected by law (see Appendix 3).**Sources of information:** He *et al.* (1990); Zhang (2007); IUCN (2008).**[10] *Craigia kwangsiensis* H.H. Hsue (Malvaceae)****Synonym(s):** —**Vernacular name(s):** *gui dian tong* (桂滇桐).**Brief description:** Deciduous tree, up to 12 m.**Geographic range and ecology:** Langping, Tianlin County (NW Guangxi), ca. 1400 m. Evergreen broad-leaved forests (on limestone).**Population size:** Only known from the type. Probably extinct (it has not been relocated since 1982).**Threats:** Habitat destruction (deforestation)**Conservation measures:** In-situ or ex-situ conservation measures are unknown; taxon protected by law (see Appendix 3).**Sources of information:** Tang *et al.* (2007); IUCN (2008).**[11] *Euryodendron excelsum* Hung T. Chang (Theaceae)****Synonym(s):** —**Vernacular name(s):** *zhu xue mu* (猪血木).**Brief description:** Evergreen tree, 15-25 m tall and to 106 cm dbh (Fig. 1).**Geographic range and ecology:** Bajia, Yangchun County (SW Guangdong), ca. 160 m. Open broad-leaved evergreen forests.**Population size:** Only 179 individuals remain in the wild (although most are saplings: there are only 23 individuals with ≥ 15 cm dbh).**Threats:** Habitat destruction and fragmentation (which have caused its recent extirpation from Guangxi); overexploitation (use as timber).**Conservation measures:** Cultivated in botanical gardens; artificial propagation has been carried out (about 10000 saplings have been obtained); programs of introduction (in Xishuangbanna, Yunnan) and reinforcement (of Bajia population) are underway; taxon protected by law (see Appendix 3).**Sources of information:** Shen *et al.* (2008); Shen S. (pers. comm.), Wang Y.-H. (pers. comm.).

Appendix 1. (Cont.)

[12] *Gleditsia japonica* Miq. var. *velutina* L. Chu Li (Fabaceae)

Synonym(s): *Gleditsia horrida* Willd. subsp. *velutina* (L. Chu Li) Paclt; *Gleditsia vestita* Chun & F.C. How ex B.G. Li

Vernacular name(s): *rong mao zao jia* (绒毛皂荚).

Brief description: Deciduous, broadleaved tree, 8-13 m tall, dbh 30-80 cm.

Geographic range and ecology: Nanyue Mountain, Hengshan County (E Hunan), 750 m. Evergreen and deciduous broad-leaved forests.

Population size: Only 2 wild individuals remain.

Threats: Habitat destruction; use as timber; no regeneration in the natural population.

Conservation measures: The extant individuals are located within a nature reserve; cultivated in botanical gardens (ca. 2000 individuals are planted in an experimental plot in Nanyue Arboretum); artificial propagation has been carried out; taxon protected by law (see Appendix 3).

Sources of information: Guo *et al.* (2003); Guo (2004); IUCN (2008).

[13] *Lithocarpus formosanus* (Skan) Hayata (Fagaceae)

Synonym(s): *Pasania formosana* Schottky; *Quercus formosana* Skan; *Synaedrys formosana* Koidz.

Vernacular name(s): *tai wan ke* (台湾柯).

Brief description: Medium-sized evergreen tree.

Geographic range and ecology: Nanren Mountain, Hengchun Peninsula, Pingdong County (S Taiwan), 100-500 m. Mixed mesophytic forests.

Population size: 50-100 individuals.

Threats: Seed predation (squirrels); poor regeneration.

Conservation measures: The locality is included within a nature reserve; ex-situ conservation measures are unknown.

Sources of information: Chiang *et al.* (2004); IUCN (2008).

[14] *Magnolia zenii* W.C. Cheng (Magnoliaceae)

Synonym(s): *Magnolia elliptilimba* Y.W. Law & Z.Y. Gao; *Yulania zenii* (W.C. Cheng) D.L. Fu

Vernacular name(s): *bao hua yu lan* (宝华玉兰).

Brief description: Deciduous tree, up to 11 m tall and to 30 cm dbh (Fig. 1).

Geographic range and ecology: Baohua Mountain, Jurong City (SW Jiangsu), 220 m. Mixed broad-leaved forests.

Population size: 149 individuals (of these, only 38 are mature).

Threats: Poor regeneration, interspecific competition.

Conservation measures: The locality is included within a nature reserve; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: Cicuzza *et al.* (2007); BGCI (2008c); Wang *et al.* (2008a).

[15] *Ostrya rehderiana* Chun (Betulaceae)

Synonym(s): —

Vernacular name(s): *tian mu tie mu* (天目铁木).

Brief description: Deciduous tree, up to 15 m tall.

Geographic range and ecology: Tianmu Mountain (W Zhejiang), 200-400 m. Subtropical broad-leaved forests.

Population size: Only 5 individuals.

Threats: Lack of regeneration.

Conservation measures: The extant individuals are protected by a nature reserve; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: IUCN (2008); Wang *et al.* (2008b).

Appendix 1. (Cont.)

[16] *Pachylarnax sinica* (Y.W. Law) N.H. Xia & C.Y. Wu (Magnoliaceae)

Synonym(s): *Magnolia sinica* (Y.W. Law) Noot.; *Manglietia sinica* (Y.W. Law) B. L.Chen & Noot.; *Manglietiastrum sinicum* Y.W. Law

Vernacular name(s): *hua gai mu* (华盖木).

Brief description: Evergreen tree, up to 40 m tall and to 120 cm dbh.

Geographic range and ecology: Xichou and Maguan counties (SE Yunnan), 1300-1550 m. Evergreen broad-leaved forests.

Population size: About 50 individuals remain in the wild.

Threats: Habitat destruction (deforestation); no regeneration; overexploitation (use as timber).

Conservation measures: Partially protected by nature reserves; cultivated in botanical gardens and local nurseries (these latter harbour up to 5000 saplings); population reinforcements are under way (and currently showing a notable success); taxon protected by law (see Appendix 3).

Sources of information: Cicuzza *et al.* (2007); Sun *et al.* (2007); BGCI (2008c); CAS (2008); GTC (2008); Gong X. (pers. comm.).

[17] *Plantago fengdouensis* (Z.E. Chao & Yong Wang) Yong Wang & Z. Yu Li (Plantaginaceae)

Synonym(s): *Plantago erosa* Wall. var. *fengdouensis* Z.E. Chao & Yong Wang

Vernacular name(s): *feng dou che qian* (丰都车前).

Brief description: Perennial herb, up to 30 cm tall.

Geographic range and ecology: Three alluvial islets in the Yangtze River (located in Banan District, Fengdu County and Zhong County), Three Gorges Reservoir Area (C Chongqing), 100-200 m. Gravel beds.

Population size: The population size was of 290 individuals before their translocation, but it has shrunk to less than 30.

Threats: Habitat loss (inundation due to the Three Gorges Dam filling); low reproductive success.

Conservation measures: The living individuals were transferred to Wuhan Botanical Garden (and some seeds sent to Beijing Botanical Garden, where germination experiments were carried out) for their preservation; artificial propagation has shown successful results.

Sources of information: Wang *et al.* (2004, 2006); People's Daily (2008).

[18] *Sinojackia sarcocarpa* L.Q. Luo (Styracaceae)

Synonym(s): *Sinojackia oblongicarpa* Tao Chen & T.R. Cao

Vernacular name(s): *rou guo cheng chui shu* (肉果秤锤树); *huai hua cheng chui shu* (怀化秤锤树).

Brief description: Deciduous tree or shrub, 4-10 m tall.

Geographic range and ecology: Wuyou Mountain, Leshan Prefecture (S Sichuan), and Hejiatian, Huaihua Prefecture (W Hunan), 200-700 m. Evergreen broad-leaved forests.

Population size: The 2 localities altogether contain only 38 individuals.

Threats: Habitat destruction; poor regeneration; overexploitation (use as fuelwood).

Conservation measures: Although in-situ or ex-situ measures are still not implemented by governmental bodies, Luo L.Q. (who described the species) is voluntarily protecting it.

Sources of information: Luo (2005a,b); Yao *et al.* (2005); Yao X.-H. (pers. comm.).

[19] *Sinopora hongkongensis* (N.H. Xia, Y.F. Deng & K.L. Yip) J. Li, N.H. Xia & H.W. Li (Lauraceae)

Synonym(s): *Syndiclis hongkongensis* N.H. Xia, Y.F. Deng & K.L. Yip

Vernacular name(s): *kong yao nan* (孔药楠).

Brief description: Evergreen tree, up to 16 m tall and to 90 cm dbh.

Geographic range and ecology: Tai Mo Mountain (Hong Kong), ca. 450 m. Evergreen broad-leaved forests.

Population size: Only 2 individuals (one mature and one juvenile).

Threats: Other threats apart from the small population size are unknown.

Conservation measures: The locality is included within a Hong Kong Country Park; ex-situ conservation measures have still not been implemented.

Sources of information: Li *et al.* (2008).

Appendix 1. (Cont.)

[20] *Ulmus gausseii* W.C. Cheng (Ulmaceae)

Synonym(s): —

Vernacular name(s): *zui weng yu* (醉翁榆).

Brief description: Deciduous tree, up to 25 m tall and to 80 cm dbh.

Geographic range and ecology: Langya Mountain, Langya District (E Anhui), below 100 m. Broad-leaved deciduous forests.

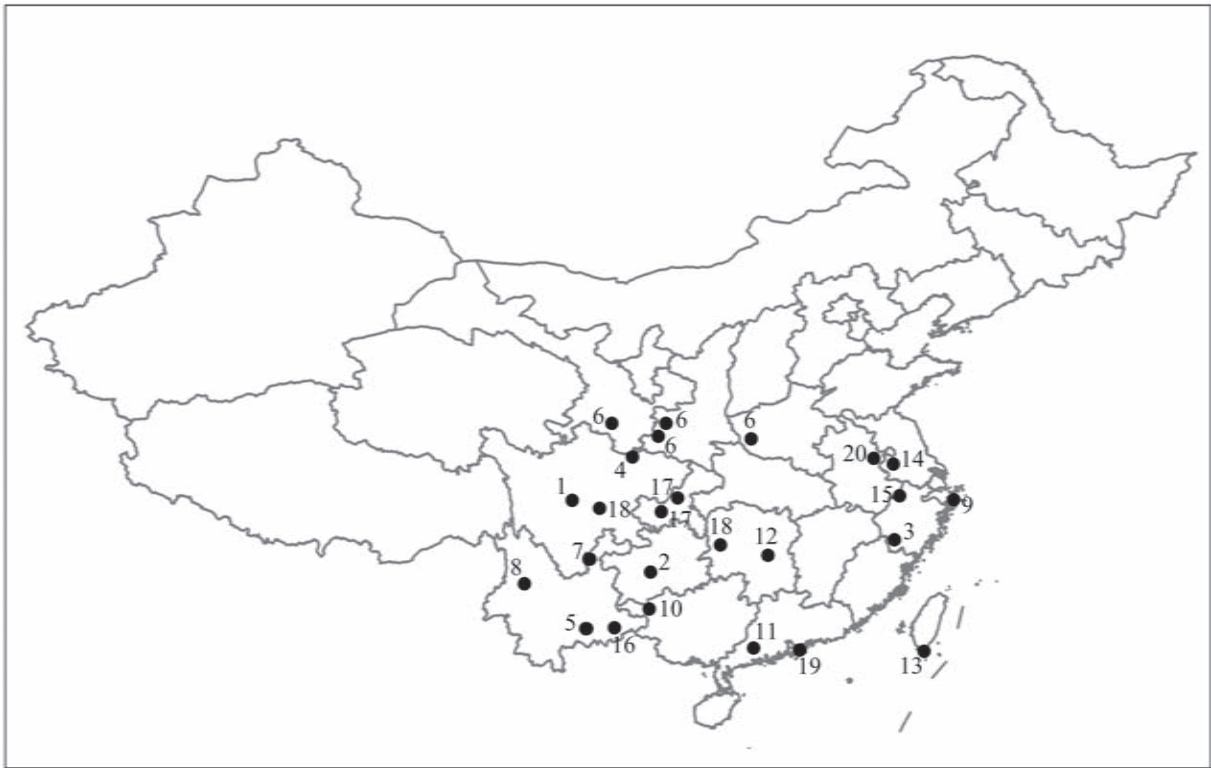
Population size: About 30 mature individuals.

Threats: Poor regeneration (most mature trees are senescent); overexploitation (use as timber).

Conservation measures: The individuals are located within a national park; cultivated in botanical gardens; taxon protected by law (see Appendix 3).

Sources of information: IUCN (2008).

Appendix 2. Geographic distribution of the 20 endangered plant taxa included in this study. The code numbers correspond to those of plant taxa in Appendix 1.



Appendix 3. Legal status and threat degree (according to different listings) of the 20 endangered plant taxa included in this study.

- A. *Catalogue of the National Protected Key Wild Plants* (1999) (I: Class I national protected key wild plants; II: Class II national protected key wild plants).
 B. *National List of Rare and Endangered Plant Species* (1984) (National protection categories (NPC): NPC-1: Species of extremely important scientific and economic significance; NPC-2: Species of important scientific and economic significance; NPC-3: Species of some scientific and economic significance).
 C. *China Plant Red Data Book* (Fu, 1992) (EN: Endangered; VU: Vulnerable; RA: Rare).
 D. IUCN threat category (2001 criteria) (EX: Extinct; EW: Extinct in the wild; CR: Critically Endangered; EN: Endangered; VU: Vulnerable).
 E. CITES listing.

	Taxa	A	B	C	D	E
PTERIDOPHYTA						
1	<i>Cystoathyrium chinense</i>	I	NPC-2	EN	CR (IUCN, 2008); EW (Zhang & Ma, 2008)	—
2	<i>Isoetes yunguiensis</i>	I	—	—	CR (Liu <i>et al.</i> , 2005)	—
GYMNOSPERMAE						
3	<i>Abies beshanzensis</i> var. <i>beshanzensis</i>	I	NPC-2	EN	CR (Wang & Xie, 2004)	—
4	<i>Cupressus chengiana</i> var. <i>jiangeensis</i>	II*	NPC-2*	VU*	CR (Wang & Xie, 2004)	—
5	<i>Cycas hongheensis</i>	I	—	—	CR (Donaldson, 2003; Wang & Xie, 2004)	Appendix II
6	<i>Picea neoveitchii</i>	II	NPC-2	EN	VU (Wang & Xie, 2004), CR (Zhang, 2007)	—
7	<i>Pinus squamata</i>	I	—	—	CR (Wang & Xie, 2004)	—
ANGIOSPERMAE						
8	<i>Acer yangbiense</i>	—	—	—	CR (Wang & Xie, 2004)	—
9	<i>Carpinus putoensis</i>	I	NPC-2	EN	CR (Wang & Xie, 2004)	—
10	<i>Craigia kwangsiensis</i>	—	NPC-3	EN	CR (Wang & Xie, 2004)	—
11	<i>Euryodendron excelsum</i>	—	NPC-2	EN	CR (Wang & Xie, 2004)	—
12	<i>Gleditsia japonica</i> var. <i>velutina</i>	II	NPC-3	EN	CR (Wang & Xie, 2004)	—
13	<i>Lithocarpus formosanus</i>	—	—	—	CR (IUCN, 2008)	—
14	<i>Magnolia zenii</i>	II	NPC-3	EN	CR (Wang & Xie, 2004)	—
15	<i>Ostrya rehderiana</i>	I	NPC-2	EN	CR (Wang & Xie, 2004)	—
16	<i>Pachylarnax sinica</i>	I	NPC-2	RA	CR (Wang & Xie, 2004)	—
17	<i>Plantago fengdouensis</i>	—	—	—	EW**	—
18	<i>Sinojackia sarcocarpa</i>	—	—	—	CR (Wang & Xie, 2004)	—
19	<i>Sinopora hongkongensis</i>	—	—	—	CR (Li <i>et al.</i> , 2008)	—
20	<i>Ulmus gaussonii</i>	—	NPC-3	EN	CR (Wang & Xie, 2004)	—
* Listed as <i>Cupressus chengiana</i> (no subspecific level is detailed).						
** Own estimations based on the available information from Wang <i>et al.</i> (2006).						