

Conifer conservation in Vietnam: three potential flagship species

Aljos Farjon, Philip Thomas and Nguyen Duc To Luu

Abstract Discoveries of new species and new records of species are the order of the day in Vietnam, a country with a high level of biodiversity and many areas still largely unexplored. In recent years many conifers have been discovered for the first time in the country, and this paper focuses on three of these. The Vulnerable *Pinus krempfii* is an endemic of exceptional scientific interest. The globally Vulnerable *Taiwania cryptomerioides*, a conifer of ancient lineage in the Cupressaceae previously only known to occur with certainty in Taiwan and the border region between Myanmar and China, is a new discovery for Vietnam, where it is Critically Endangered. The Critically Endangered *Xanthocyparis vietnamensis*, a

new genus and species in the Cupressaceae, was described in 2001 and is restricted to limestone outcrops on the border with China. All three species are of high conservation concern due to their rarity and because of threats to their survival from expanding cultivation, felling and fires. We discuss the suitability of these three conifers as flagship species to promote forest conservation in Vietnam. We also discuss the problems involved in the protection of these species, and the efforts that are currently being undertaken to conserve them.

Keywords Conifers, endemism, extinction, flagship species, *Pinus krempfii*, *Taiwania cryptomerioides*, Vietnam, *Xanthocyparis vietnamensis*.

Introduction

Vietnam is one of the most biologically diverse countries in the world, with an estimated 12,000 plant species, of which c. 10% are endemic, representing 300 families and nearly 3,000 genera (Averyanov *et al.*, 2003). The majority of species are concentrated in the montane forests, and deforestation has therefore been, and continues to be, a major problem in Vietnam, which has a rapidly growing human population of c. 77 million. It is estimated that the forest cover has been reduced to <28% of its original extent, with much of the loss occurring since 1945 (de Koninck, 1999).

Since the late 1980s the Vietnamese government has been engaged in an extensive programme of biological inventories of the remaining forests to establish a more comprehensive system of protected areas. This has resulted in many new discoveries of plants and animals. For conifers, new populations of known species, as well as new species, have been discovered in the north of the country. Since 1990, eight taxa from five genera have been recorded for the first time. The native conifers of

Vietnam are now represented by five families, 20 genera and c. 33 species (Farjon, 2001; Nguyen Duc To Luu & Thomas, 2004), six of which are endemic (*Abies delavayi fansipanensis*, *Amentotaxus hatuyenensis*, *A. poilanei*, *Pinus dalatensis*, *P. krempfii* and *Xanthocyparis vietnamensis*). The 19 Vietnamese conifers of global conservation concern are listed in Table 1. With 57% of its conifer species globally threatened, Vietnam qualifies for recognition as one of the world's hotspots as defined by IUCN's *Conifer Action Plan* (Farjon & Page, 1999).

The high proportion of threatened conifers is primarily the result of extensive deforestation caused by shifting cultivation, conversion of forest to pasture, and both clear-felling and selective felling for high value timber and non-timber products (e.g. resin, essential oils) produced by many species. Additionally, several conifers are represented by small relict populations, or as peripheral populations at the edge of the range of more widespread taxa. The Vietnamese conifers represent a readily recognized group of plants that are emblematic of the problems facing biodiversity in Vietnam and have the potential to act as flagship species (Bowen-Jones & Entwistle, 2002) for local, regional and national conservation campaigns. In this paper we discuss three of these species in detail: *Pinus krempfii*, *Taiwania cryptomerioides* and *Xanthocyparis vietnamensis*.

Pinus krempfii

The distinctive and relict *Pinus krempfii* is one of six endemic conifers in Vietnam. Its unusual flattened

Aljos Farjon (Corresponding author) Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, UK. E-mail a.farjon@rbgkew.org.uk

Philip Thomas Royal Botanic Garden Edinburgh, 20A Inverleith Row, Edinburgh, EH3 5LR, UK.

Nguyen Duc To Luu Central Forest Seed Company, Ministry of Agriculture and Rural Development, 62 Cau Dien Township, Tu Liem, Hanoi, Vietnam.

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Table 1 Conifer species occurring naturally in Vietnam (Farjon & Page, 1999, and recent additions and amendments by the IUCN Species Survival Commission Conifer Specialist Group), with their IUCN Red List status (IUCN, 2003).

Species ¹	Red List status ²
<i>Abies delavayi</i> Franchet subsp. <i>fansipanensis</i> (Q. P. Xiang) Rushforth	VU
<i>Amentotaxus argotaenia</i> (Hance) Pilg.	VU
<i>Amentotaxus hatuyenensis</i> Hiep	EN
<i>Amentotaxus poilanei</i> (Ferré & Rouane) D. K. Ferguson	VU
<i>Amentotaxus yunnanensis</i> H. L. Li	EN
<i>Calocedrus macrolepis</i> Kurz	VU
<i>Cephalotaxus mannii</i> Hook. f.	VU
<i>Cunninghamia konishii</i> Hayata	VU
<i>Fokienia hodginsii</i> (Dunn) A. Henry & A. A. Thomas	NT
<i>Glyptostrobus pensilis</i> (Staunton) K. Koch	DD
<i>Nageia fleuryi</i> (Hickel) de Laubenfels	EN
<i>Pinus dalatensis</i> Ferré	VU
<i>Pinus fenzeliana</i> Hand.-Mazz.	NT
<i>Pinus krempfii</i> Lecomte	VU
<i>Pinus wangii</i> Hu & W. C. Cheng	EN
<i>Pseudotsuga sinensis</i> Dode var. <i>sinensis</i>	VU
<i>Taiwania cryptomerioides</i> Hayata	VU
<i>Tsuga dumosa</i> (D. Don) Eichler	NT
<i>Xanthocyparis vietnamensis</i> Farjon & Hiep	CR

¹Nomenclature follows Farjon (2001).

²CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; DD, Data Deficient.

needles, absence of ray tracheids and other unusual wood characters make it unique within the genus. Since its description (Lecomte, 1921, 1924) there has been controversy over its classification, with some authorities placing it in the monotypic genus *Ducampopinus* (Chevalier, 1944) and others including it either in the monospecific subgenus *Ducampopinus* within the genus *Pinus* or within various sections of the subgenus *Strobos* (de Ferré, 1953; Gaussen, 1960; Critchfield & Little, 1969; Price *et al.* in Richardson, 1998). Recent morphological and molecular work has supported its inclusion within the subgenus *Strobos* although there are still unanswered questions about its relationship to other taxa (Wang *et al.*, 2000). Prior to the discovery of *X. vietnamensis*, *P. krempfii* was the most well known Vietnamese conifer outside Vietnam. Within Vietnam, its scientific value has long been recognized (Schmid, 1974; Nguyen Tien Hiep & Vidal, 1996; Phan Tuc Vat, 1996; Vu Van Dung, 1996).

P. krempfii forms a broad domed, emergent tree up to 30 m high (Plate 1) with basal diameters reaching 4 m (Williams, 1999). Trees up to 2,000 years old have been reported (Schmid, 1974) although no tree ring counts have been published. *P. krempfii* has been recorded from three provinces in the southern highlands: Lam Dong, Khanh Hoa and Dac Lac (Nguyen Duc To Luu & Thomas, 2004). The majority of the populations are



Plate 1 *Pinus krempfii* as emergent trees with umbrella-shaped crowns in montane forest of the southern highlands of Vietnam.

known from the areas near the Bi Doup massif (12°08'N, 108°40'E) that straddle the borders of those provinces. Recently, a population has been recorded from the Chu Yang Sin massif in Dac Lac (12°24'N, 108°26'E) (Le Trong Trai *et al.*, 1996) and it is likely that smaller populations exist on surrounding massifs (Businsky, 1999). *P. krempfii* occurs over 1200–2000 m altitude in closed canopy forests dominated by evergreen members of the Fagaceae and Lauraceae. It may be locally dominant, often occurring on the tops and upper slopes of flattened ridges in moist soils with well-developed humus layers (Nguyen Tien Hiep, 1996; Vu Van Dung, 1996); little is otherwise known about its ecology. From field observations made at two sites (Cong Troi and Gia Rich), *P. krempfii* appears to be shade tolerant, persistent within a closed canopy and able to compete to some extent with associated angiosperms. Regeneration was found to be abundant, with several stages present. The absence of traits that are usually associated with fire resistance or fire evasion in pines, such as thick bark, serotinous cones and resprouting (Keeley & Zedler in Richardson, 1998), suggests other types of disturbance, such as cyclones, may be more important for its regeneration. Its restriction to mesic habitats in a limited area where other relict taxa have been recorded may reflect its ancient history.

P. krempfii is categorized as Vulnerable on the IUCN Red List (IUCN, 2003) according to criteria (IUCN, 1994) B1+2c; its area of occupancy is estimated to be <2,000 km² (B), there are fewer than ten distinct locations (1) and there has been a continuing decline in the area, extent and quality of its habitat (2c). This decline has been attributed to the effects of the Vietnam War in the 1960s and the clearance of land for agriculture in the following decades (Williams, 1999). Its limited distribution and the inaccessibility of much of its habitat mean that there has been little direct exploitation, although its timber is known to have physical and mechanical properties similar to the exploited *P. kesiya* (Vu Van Dung, 1996).



Plate 2 Dead *Pinus krempfii* standing above secondary vegetation in disturbed forest.

There have been reports of incidental felling in areas where it occurs with the harvested *Fokienia hodginsii* (Businsky, 1999).

The most serious current threat to *P. krempfii* is habitat fragmentation resulting from continuing slash and burn cultivation and the conversion of lower altitude forests to fire-prone *P. kesiya* forests (Plate 2). An increase in the frequency of fires across the whole of the Dalat plateau has been reported and is evident in areas such as Cong Troi near Dalat (Davis *et al.*, 1998; Stattersfield *et al.*, 1998; Anon., 2001).

The areas in which *P. krempfii* occurs have been recognized as centres of diversity, with records of >2,000 higher plant species, >200 species of birds, and populations of important primates (Davis *et al.*, 1998; Stattersfield *et al.*, 1998; Anon., 2001). These areas are also critical for the protection of watersheds. The Vietnamese government, assisted by organizations such as WWF and BirdLife International, has made efforts to facilitate the *in situ* conservation of the remaining forests. In 1986 the Thong Da Nhim – Bi Doup Nature Reserve (72,573 ha) and the Chu Yang Sin Nature Reserve (54,227 ha) were established as provincial reserves within the Special Use Forest System (Anon., 2001). In 2002 the Chu Yang Sin reserve was upgraded to National Park status (Anon., 2002a). Core areas, surrounded by buffer zones, have been set aside as strict nature reserves. These areas contain the vast majority of the remaining *P. krempfii* populations.

These *in situ* strategies are part of a wider strategy to conserve the remaining biodiversity of the Dalat plateau, rather than for the specific conservation of *P. krempfii* (Wege *et al.*, 1999). However, presence of *P. krempfii* in these areas provides an added impetus for conservation. Within Vietnam a limited amount of research into the biology and ecology of *P. krempfii* has been initiated. Survey and inventory work in Bi Doup and the Chu Yang Sin is ongoing (Nguyen Tien Hiep, pers. comm.). Staff

from the Forest Science Institute have attempted to establish a small *ex situ* planting near Dalat (Nguyen Hoang Nghia, 2001). Internationally *P. krempfii* continues to attract a high level of interest from taxonomists, scientists and horticulturalists.

Taiwania cryptomerioides

Taiwania cryptomerioides is the only species currently recognized in its genus. *Taiwania* is of interest scientifically because of its basal relationship in Cupressaceae (Gadek *et al.*, 2000) and its evolutionary and biogeographical relict status. The current distribution is highly disjunct. Until recently there were only two areas where it is indisputably indigenous: Taiwan and the border region between Myanmar and China (Yunnan and Xizang), with most of the known populations in Yunnan. In these areas *Taiwania* has been heavily exploited for its fragrant timber, which is highly valued for coffins and furniture; it is also used in reforestation schemes in montane areas of southern China as a high value medium- to long-term tree crop. Several other known localities in southern China are probably cultivated trees rather than indigenous populations (Farjon, in press). The discovery of a new population in Vietnam that is so disjunct from its indigenous range raised the possibility that the new population may be cultivated trees.

T. cryptomerioides was first observed in October 2001 (Nguyen Tien Hiep *et al.*, 2002) in Liem Phu commune, Van Ban District, Lao Cai Province, in the upper drainage of the Nam Qua River, which is in the Hoang Lien Son mountain range (21°56'N, 104°19'E) at 1,800–2,100 m altitude. An estimated total of 90–100 living mature trees of *T. cryptomerioides* were observed (Farjon, 2002). The area of occurrence covers *c.* 3 km² but the area of occupancy is only 1–2 ha. The proportion of the area of occurrence still covered by mature evergreen forest is *c.* 10–20%; several trees of *Taiwania* are now standing on the edge of, or in, secondary vegetation dominated by the tall grass *Imperata cylindrica* and/or bracken fern *Pteridium aquilinum*.

Mature *T. cryptomerioides* were found emerging from a canopy of remnants of mature, primary upper montane evergreen forest (Plate 3) dominated by Fagaceae, Lauraceae and Magnoliaceae, with occasional specimens of *Fokienia hodginsii* at 1,750–2,100 m altitude. The largest trees were *c.* 35 m in height and *c.* 100 cm diameter at breast height, which is small for this species. A number of mature trees were seen growing from rock crevices in which the seedlings must have germinated. The distribution of mature trees, mostly as solitary individuals scattered in angiosperm forest, reflects the natural mature population of surviving emergents characteristic of conifers dependent for regeneration on infrequent



Plate 3 *Taiwania cryptomerioides* as an emergent conifer in fragments of montane rainforest, Huanglien Mountain Range, northern Vietnam.

episodic disturbance events (Veblen & Stewart, 1982; Enright & Hill, 1995), of which *Taiwania* is an example. The paucity of juveniles confirms that effective regeneration has been episodic and probably antedated the increased human impact in the area (see below).

The altitudinal range of this population falls within that for *Taiwania* (1,750–2,900 m). Its forest habitat is similar to that known from Taiwan and Yunnan, dominated by angiosperms characteristic of upper montane evergreen forest with a strong representation of Sino-Himalayan elements. The Hoang Lien mountains, where the new population occurs, represent an ancient connection with the Sino-Himalayan region as part of the Mesozoic Indo-Sinian orogeny. Numerous taxa with essentially Sino-Himalayan ranges have penetrated into Vietnam along this high mountain range, which rises to 3,143 m. (Averyanov *et al.*, 2003). These facts confirm that this population is indigenous and constitutes a third disjunct area of the present distribution of this species.

Globally *T. cryptomerioides* is categorized as Vulnerable on the IUCN Red List (IUCN, 2003). The population in northern Vietnam is categorized as Critically Endangered (Farjon & Page, 1999) according to criteria (IUCN, 1994) A1c (population reduction of at least 80% over the last three generations), B1 + 2b – e (extent of occurrence <100 km², severely fragmented and continuing decline according to several criteria), and C2a (population estimated <250 mature individuals, continuing decline and severely fragmented). The principal threat faced by this population is continuing deforestation accompanied by an increased incidence of fires. The local H'mong people use fire to increase land available for grazing livestock as well as to clear new areas for maize cultivation and to maintain existing maize fields. The result is a mosaic of pastures, maize fields and forest fragments. Some of the remaining *Taiwania* trees receive some measure of protection from fires due to their location on steep rocky precipices where fuel is limited. Many other trees



Plate 4 The houses of the H'mong people are made of planks split by axe from trunks of *Taiwania* and *Fokienia* (Cupressaceae).

have deep basal fire scars. The relatively thin bark of *Taiwania* means that it only has a limited capacity to survive hot fires and consequently it can only be a matter of time before all trees and forest remnants are lost. Several planted trees, reportedly collected as seedlings by villagers, occur in Pin Ngai village on the Ta Xa River, a watershed to the south. In this and another village nearby (Lung Cung) wood shingles derived from *Taiwania* and *Fokienia* are used for the roofs of small houses (Plate 4).

The conservation of *Taiwania* at Van Ban presents many difficulties as well as some opportunities. *Taiwania* could be added to the list of species for which there is a total logging and harvesting ban (Council of Ministers, Decision 18, 1992). However, logging is not the most direct threat to this population. Alternatively, the Van Ban area could be proposed as a protected area and eventually declared as a reserve. This could be a slow process and would not necessarily reduce the level of threat from deliberate burning or wildfires in the surrounding areas, certainly not within the next 5 years. Deliberate burning of the remaining forest and the surrounding grasslands is the result of the land use and activities of the local people so it is with them that the solution must ultimately be found.

The Van Ban district forms part of a European Union Tropical Forestry Project (*Community Based Conservation in the Hoang Lien Mountain Ecosystem*) which builds on funding from a UK Government Darwin Initiative-funded project run by Fauna & Flora International in partnership with the Lao Cai Provincial Forest Protection Department. This project has proposed a conservation programme for the *Taiwania* population in which those people who pose the greatest threat to the trees could become their guardians. Field research has been initiated into the socioeconomic characteristics of the communities and their awareness of, and attitudes to, *Taiwania* and to conservation in general. Depending on the results of this, stewardship agreements could be agreed that could

extend to the 'adoption' of individual trees by families. Fire prevention measures in the form of strategically positioned firebreaks could be built by the local communities. The success of such a campaign would depend strongly on the promotion of the value of the *Taiwania* trees to the local people as well as recognition of that value by the provincial and district authorities and the Van Ban Forest Enterprise on whose assigned land *Taiwania* is located. Negotiations are currently in progress for more comprehensive *in situ* work.

As a safeguard, an *ex situ* programme is complementing the *in situ* work. This aims to provide material for potential restoration work as well as for plantation trials both in the near future and in the longer term. The work involves the Vietnam Tree Seed Project, the International Conifer Conservation Programme and the Central Forest Seed Company, Hanoi. In December 2003 a team carried out a successful programme of seed collecting, and subsequent seed testing and germination trials (N.V. Canh, unpub. data) have shown that the remaining trees are still capable of producing viable seed, making restoration and utilization work more likely. *Taiwania*, with its relatively fast growth and valuable timber, has the potential for use in highland forestry in different areas of Vietnam including Van Ban. In the longer term, plantations established in degraded areas may help to satisfy the demand for timber, and relieve some of the pressures on the remaining primary forests.

Xanthocyparis vietnamensis

On a botanical expedition in October 1999 to remote karst limestone mountains north-west of Quan Ba, close to the Chinese border in the northern Vietnamese province of Ha Giang, an unidentified conifer was found growing on a summit ridge. Subsequently, after collection of more material early in 2001, this conifer was identified and described as a new genus and species in the Family Cupressaceae (Farjon *et al.*, 2002). One of the striking morphological features of *Xanthocyparis vietnamensis* is the occurrence of two distinct types of leaves on many mature trees. It has both branches with juvenile, needle-like leaves and ones with mature, scale-like leaves. Only the latter type bears either male or female cones. The trees are relatively small, up to 10–15 m tall and with diameters up to 50 cm, although a few trees of 80 cm diameter have been found (Plate 5). They are restricted to steep and narrow mountain ridges in association with several other conifers and angiosperms. (Averyanov *et al.*, 2002; To Quang Thao *et al.*, 2004).

X. vietnamensis is restricted to three communities, Bat Dai Son, Can Ty and Thanh Van, at c. 23°08'N, 105°E (maps in Averyanov *et al.*, 2002). The limestone massif is steepest on the north-east and east side where the Mien River has cut a deep valley. The altitude of the massif is

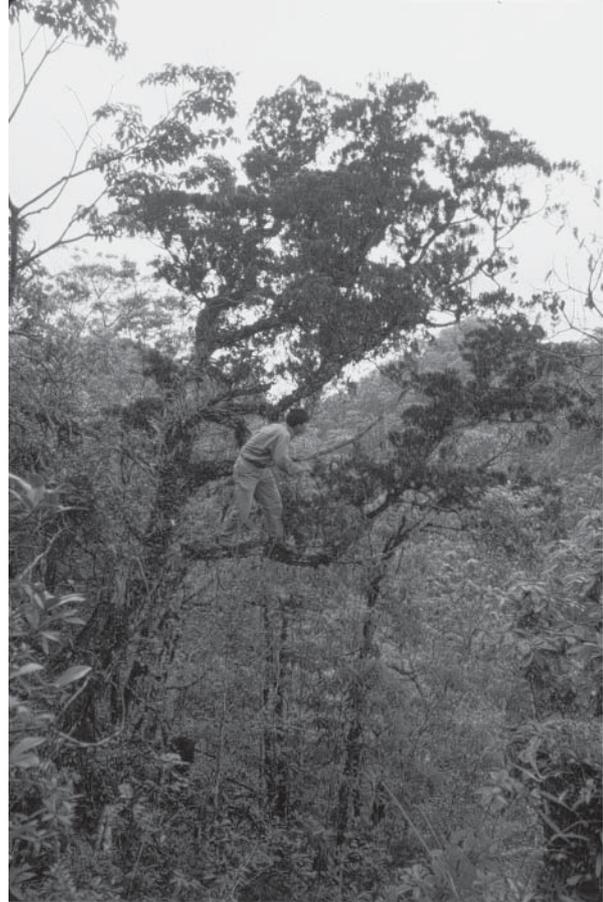


Plate 5 One of the largest *Xanthocyparis vietnamensis* grows on a limestone ridge.

c. 800–1,200 m. This conifer occurs on high ridges and summits in eroded karst limestone with little or no soil formation (Plate 6). It is an occasional component in mixed conifer-angiosperm ridge forest dominated by another conifer, *Pseudotsuga sinensis*, and accompanied by several other mostly rare conifers and numerous



Plate 6 *Xanthocyparis vietnamensis* grows on ridges and summits of steep karst limestone near the Chinese border, northern Vietnam.

woody angiosperms. Epiphytes, especially orchids, ferns and mosses, are numerous. On lower slopes, much of the forest has been cleared to make way for crops, mostly maize, planted by the local H'mong population who live in hamlets or villages in the valley of the Mien River and in valleys above it. This lower forest is of a different type, dominated by angiosperms, including the palm *Caryota*, and it appears to have few if any conifers (A. Farjon, pers. obs.).

The wood of *X. vietnamensis* is locally valuable. *Xanthocyparis*, along with *Fokienia*, *Cupressus*, and *Taiwania*, are a group of conifers with durable, often fragrant wood, which is highly sought after in Asian markets. Incense burning of foliage of *Cupressus*, *Platyclusus* and *Juniperus* is also widespread, especially in Buddhist traditions. Felled trees have been observed. On the most inaccessible ridges *Xanthocyparis* is probably safe from felling, but these specimens may be less vigorous and genetic depletion is therefore a possibility. There is currently no evidence of frequent fires on these ridges. However, in other parts of north-eastern and southern Vietnam conversion of valley forests for agricultural production and the disturbance associated with selective felling (especially for conifers) in the forests above the valleys results in an increased susceptibility of higher altitude forests to wildfires. In the longer term, fire may become the principal threat.

Xanthocyparis was discovered during a wider evaluation of the biodiversity of the limestone mountains of the Ha Giang region. The results of these surveys led to the declaration of >10,000 ha of the Bat Dai Son Mountain Range as a Provincial Protected Area, which has been included on the 2010 list of Proposed Protected Areas as a National Nature Reserve. Funding has already been approved for the protection of a 700 ha section that adjoins the Chinese border (Anon., 2001, 2002b; Averyanov *et al.*, 2002). The most recent survey located 290 mature individuals scattered over a series of narrow ridges within an area of 20.3 km², all of which are within the reserve. As a result, previous conservation assessments (Averyanov *et al.*, 2002; Farjon *et al.*, 2002) have been refined, and its current Red List status is Critically Endangered based on criteria (IUCN, 2001) B1ab(v) and B2ab(v), i.e. both extent of occurrence <100 km² (B1) and area of occupancy <10 km² (B2), with increase in fragmentation (a) and decline in number of mature individuals (b(v)) (To Quang Thao *et al.*, 2003).

Within the proposed protected area a system of forest ownership has been introduced. Families have been allocated areas of forest from which they are allowed to extract dead timber for fuel along with non-timber forest products. Additionally, each family has a responsibility for protecting their allocated area of the forest. Logging, as in other parts of Vietnam, has been banned (Anon., 2002b). However, illegal logging of *Xanthocyparis* and

Pseudotsuga continues, partly to satisfy local needs for house construction but also in response to cross border demand. As a result, *ex situ* programmes have been initiated. Cuttings from all known populations were collected for propagation at the Central Forest Seed Company nursery in Hanoi. These collections have been used for propagation trials, with surplus material being used for replanting in the Ha Giang area, initially to establish trial plantations with the local villages. It is intended that the replanting programme will be complemented by awareness raising campaigns focusing on the unique biodiversity contained within the forests and exemplified by endemics such as *X. vietnamensis* (Nguyen Tien Hiep, pers. comm.).

Discussion

These three conifer species have a high scientific value as endemics (*P. krempfii* and *X. vietnamensis*) or as isolated relict populations (*T. cryptomerioides*) of monotypic genera that were once more widespread. All have restricted distributions and low rates of recruitment, and at least *P. krempfii* and *T. cryptomerioides* are dependent on episodic disturbance events over long (by human standards) time intervals for their effective regeneration.

P. krempfii and *T. cryptomerioides* are threatened primarily by forest degradation and deforestation caused by shifts in land use. For the former, these processes are not of such an immediate threat, as the majority of the *P. krempfii* populations, although small, are embedded within larger areas of primary and less disturbed forest. Effective protection of the wider habitat of *P. krempfii* through traditional *in situ* approaches may be sufficient for its long-term conservation. For *T. cryptomerioides*, already restricted to a small population in a forest remnant that lies within a severely fragmented landscape, the threat from traditional land-use practices is more immediate. Its conservation requires a concerted campaign to persuade local stakeholders of the value of conserving the species. The threats facing *X. vietnamensis* may be more difficult to counter. There is a significant, although localized, demand for its timber, which extends across the border into neighbouring China. Roadside checkpoints are impractical as most timber is cut *in situ*, with the logs carried out on people's backs along small trails. Meeting the demand for the wood through cultivation and plantation is a possibility, but it will be some time before harvestable trees can be produced, even if it proves possible to establish it away from its specialized habitat. However, this is not a reason to delay such trials, especially if they are linked to awareness raising campaigns about sustainable management.

The flagship species concept may be an appropriate way of supporting conservation measures for these three species. The effectiveness of this concept and the most

appropriate criteria to use in the selection of suitable species has been debated (Caro & O'Doherty, 1999; Entwistle, 2000; Henry *et al.*, 2001). Bowen-Jones & Entwistle (2002) proposed a set of 10 criteria for choosing and evaluating the use of flagship species in the context of locally focused conservation programmes. To these, we have added two further criteria, scientific value and utilization. Scientific value reflects taxonomic and evolutionary distinctiveness that emphasizes the uniqueness of the species at a wider level. The realization that your village or your local area is the custodian of a remarkable tree or animal that occurs nowhere else in the world can

have a powerful influence. This could also be a useful tool for relating local conservation issues to wider regional, national and international problems. Utilization refers not only to how the species is used, but also its potential use. We believe that long-term *in situ* conservation is intimately linked with the sustainable use of natural resources in *in situ* and *ex situ* contexts, and therefore the value or potential value of a particular species should be taken into account when planning conservation programmes. This point is particularly relevant to *Taiwania* and *Xanthocyparis*. Table 2 evaluates each species according to these 12 criteria.

Table 2 Assessment of three potential flagship species according to the criteria (1–10) of Bowen-Jones & Entwistle (2002), with the addition of two further criteria (11–12).

Criteria	<i>Pinus krempfii</i>	<i>Taiwania cryptomerioides</i>	<i>Xanthocyparis vietnamensis</i>
1. Geographical distribution (local/non-local)	Endemic to adjoining border areas of 3 provinces in S Vietnam	Highly localized; restricted to one commune	Highly localized; endemic to 3 communes in N Vietnam
2. Conservation status	Vulnerable	Critically Endangered in Vietnam, globally Vulnerable	Critically Endangered
3. Ecological role (keystone, umbrella or indicator species)	Locally dominant emergent, structurally important in biodiverse forest	Locally dominant emergent, structurally important in forest	Forms part of canopy of unique krumholtz forest with exceptional biodiversity values
4. Recognition	Internationally & nationally renowned	Highly recognizable & internationally renowned; national awareness is recent	Recently described & named; local people are generally able to recognize this species
5. Existing usage (as a symbol or motif for other organizations or products)	Not known to be used as a symbol by any organizations or for any product	Not known to be used as a symbol by any organizations or for any product (newly discovered within Vietnam)	Not known to be used as a symbol by any organizations or for any product (newly discovered)
6. Charisma	Large size & emergent habit make it a feature of the local landscape	Size & characteristic shape gives impression of grandeur and durability	None
7. Cultural significance (folklore, artwork, crafts)	No known local cultural significance	No known local cultural significance	This & similar foliage used for incense burning in Buddhist rites
8. Positive associations	Local peoples' sense of importance of their area & their national identity enhanced by repeated visits of outsiders	Local peoples' sense of importance of their area & their national identity enhanced by repeated visits of outsiders	Local peoples' sense of importance of their area & their national identity enhanced by repeated visits of outsiders
9. Local knowledge	Local people aware of the tree	Local villagers aware of the tree; some cultivation in villages	Villagers aware of tree & its increasing rarity; very limited cultivation
10. Local names	Locally known as <i>Thông lá dẹt</i>	No specific local name	No specific local name
11. Scientific value	High; relict species	High; relict species previously only known from 2 highly disjunct areas in Asia	High; recently discovered
12. Utility	Not used locally	Locally used for construction, some trees cultivated in local villages. Highly valued for coffins & fine crafts in other areas, where scented wood is thought to delay decay	Locally used for construction, highly valued for coffins & fine crafts, possibly incense & fire-sticks. Some trees cultivated in local villages; cross border trade

All species meet at least some of the criteria. *P. krempfii* meets the fewest as it is the least threatened and has no known local significance or utility. Despite this, its national and international stature as a species of high scientific importance make it a suitable species for raising public awareness and emphasizing the general value of *in situ* conservation of the remaining forests on the Dalat plateau. *Xanthocyparis* and *Taiwania* meet most of the criteria. Both of these species are cultivated on a small scale at a local level, indicating that people are aware that they are or have been using a limited resource and that there are alternative ways of utilizing it. All three species could be suitable for use as flagship species to promote local forest conservation. In each case, programmes focusing on individual species could act as models for programmes in other areas as well as for efforts to raise awareness at national and international levels for the problems facing biodiversity conservation in Vietnam.

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Biographical sketches

Aljos Farjon's research focuses on conifers, especially the families Cupressaceae and Pinaceae. He is also Chairman of the IUCN Species Survival Commission Conifer Specialist Group and coordinates the evaluations of this group of species for the *IUCN Red List of Threatened Species*.

Philip Thomas is involved in conservation projects with the International Conifer Conservation Programme that focus on the integration of *in situ* and *ex situ* conservation in Vietnam, China and Chile.

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