

# Cycad propagation by rural nurseries in Mexico as an alternative conservation strategy: 20 years on

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**Summary.** Propagation of the cycad *Dioon edule* aimed at sustainable management in the state of Veracruz, Mexico has been ongoing since 1990 under the supervision of staff at Francisco Javier Botanic Garden, with the principal objectives of addressing illegal trafficking and habitat destruction. Plant sales have been limited. Nevertheless these, along with the sale of other managed forest products, have given the cycad producers and other villagers enough incentive to conserve 80 hectares of cycad habitat and to discourage illegal collecting. This model was taken up by four similar nurseries in the buffer zones of two biosphere reserves in Chiapas for the propagation of four additional cycad species and two endangered *Chamaedorea* palms. A further biosphere reserve in Puebla hosts a similar nursery for the critically endangered *D. caputoi*. Here the producers are paid through the Reserve authority for cultivation and reintroduction of the cycad. All species were studied at the population level prior to and during nursery establishment. Cultivation knowledge has been passed on to the farmers as well as limited help in marketing. Seedling reintroduction experiments have been carried out but further demographic studies of *D. edule* and *C. mirandae* have given reason to re-think reintroduction strategies. There is great potential for these nurseries to act as shelter for rescued plants during civil engineering projects. The marketing problem is still an issue and has been approached by the involvement of conservation authorities in Chiapas to assist the producers with permit paperwork and to seek markets. This experience is an important example of botanic garden extension to rural communities in Mexico that covers several articles of the Convention on Biological Diversity.

**Key Words.** Cultivation, endangered species, reintroduction, sustainable management.

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## Introduction

### Brief history of the Clavijero Botanic Garden

The Jardín Botánico Francisco Javier Clavijero (JBC), now in its 32nd year, was aided by Kew during its creation and can be considered an ‘offspring’ of Kew. This was on the initiative of Dr Arturo Gómez-Pompa who invited Prof. Pat Brenan, then Director of Kew, to see the garden project in Xalapa. This marked an important phase in the Garden’s development when Prof. Brenan, with aid from the British Council in Mexico City, commissioned Ian Beyer, then Deputy Curator at Kew, to work with the first author on a basic design for the fledgling botanic garden during April 1978. The first author attended the Kew conference on *The Practical Role of Botanic Gardens in the Conservation of Rare and Threatened Plants* during September 1978 and presented a paper on the founding of the JBC (Vovides 1979) and stayed on for a three month internship in the Kew Living Collections Department to gain insights on the running of a major botanic garden. In 1981, Kew horticulturist Graham Pattison

accepted a five-year post to help further develop the garden.

The JBC was then a new concept in regional botanic gardens, devoted to local floras with an emphasis on education, conservation and propagation of threatened species, a concept largely born from the 1975 *Kew Conference on Conservation of Threatened Plants* (Simmonds *et al.* 1976). One of the main missions of the JBC is outreach to communities and assessment in alternative conservation strategies, workshops, grassroots horticultural courses and projects such as propagation of threatened species in rural nurseries.

### Botanic garden outreach

During a demographic study of *Dioon edule* Lindl., many decapitated adult plants were observed as well as a high mortality rate in germinated seedlings (Vovides 1990). The decapitated leaf crowns of *D. edule* are peddled by street sellers as ornamental plants and soon become infected by fungal pathogens and die when planted, an activity that is illegal under the

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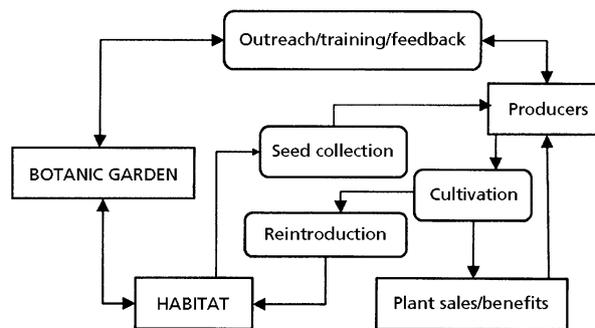
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Norma Oficial Mexicana (Anon. 1994). The existing national demand for plants prompted us to carry out germination trials at the JBC that showed a germination rate of over 90%. Although growth of the cycad is slow, cultivation is relatively easy and readily adaptable to conditions with minimum infrastructure. Therefore outreach to “campesinos” (peasant farmers) to teach them to grow the plants was made by the Garden staff. In 1990 the villagers at Monte Oscuro, Veracruz, were invited to take part in a local project in which wild collected seeds from their ejido<sup>1</sup> lands are propagated in low-investment backyard nurseries (Vovides & Iglesias 1994). The principal objective of this venture is to encourage incentive for conservation through propagation by a system of harvesting seed, sowing and cultivation and eventual sales. In return, the farmers pledge to conserve the habitat, discourage illegal extraction and reintroduce back into the wild a small percentage of their production in order to compensate for seed removal. All this is additional to the producers’ traditional activities of citrus and coffee plantations. This has encouraged an ownership value of the populations and an incentive to conserve 80 hectares of tropical dry forest habitat of the cycad as an ejido reserve (for details on nursery structure and management see Vovides 2008). Illegal collecting has been discouraged at Monte Oscuro after reports to authorities leading to arrests (Vovides *et al.* 2002) but this activity has not stopped outside the ejido reserve. The Monte Oscuro village community manages this reserve, not only for cycad conservation but also for harvesting products such as wood (for home-use only and not resale) and also young emergent leaves of the fan palm *Brahea dulcis* Mart. for the manufacture of religious artefacts for the “Domingo de Ramos” (Palm Sunday) celebrations of the Roman Catholic Church. The surrounding forests beyond the ejido limits are somewhat degraded and illegal extraction of forest resources occurs. This situation is particular only to the Monte Oscuro ejido reserve, since the other nurseries in Chiapas and Puebla are in protected Biosphere Reserves, where logging and other similar activities are prohibited in the nuclear zones and controlled in the buffer zones. The producers were given basic horticultural training, continuous assessment and workshops at the Botanic Garden.

The Monte Oscuro nursery is a forerunner of a type of nursery known as a Unidad de Manejo y Aprovechamiento de la Vida Silvestre (UMA, or wild-life management unit). They aim towards ecologically friendly activities by means of conservation through propagation, plant sales and reintroduction (Fig. 1). The UMAs operate on private or ejido lands, as well as



**Fig. 1.** Flow diagram of the UMA nursery concept combining research at habitat, developing a conservation strategy through seed collection, cultivation, plant sales and reintroduction into habitat.

in biosphere reserves, and are encouraged by the Mexican environmental authorities. The nurseries are permitted and registered with the environmental protection authority SEMARNAT (Spanish acronym for the secretariat for the environment and natural resources) that require a management plan of the nursery, inventory, annual reports on seed collection, propagation and sales. In return the producers are required to conserve the natural habitat as their seed source and to carry out reintroduction of nursery produced plants to compensate for seed removal.

These nurseries and botanic garden outreach activities are in accordance with Articles 9, 13, 18 of the Convention for Biological Diversity (CBD) regarding *ex-* and *in-situ* conservation in the country of origin, education and awareness as well as technical and scientific collaboration (Given 1997).

### Further Establishment of Nurseries

In 1991 further nurseries were established by researchers of the Universidad Veracruzana along coastal southern Veracruz for the propagation of *Zamia furfuracea* L.f. and in cloud forest habitat near Xalapa for *Ceratozamia mexicana* Brongn. (Vovides *et al.* 2002). During 1995 the second author initiated nurseries in the Ejido Andres Quintana Roo, municipality of Jiquipilas in the Central Depression of Chiapas, with propagation of *Dioon merolae* De Luca, Sabato & Vázq. Torres. During 1997 and 1998 nurseries were also initiated in La Sepultura Biosphere Reserve in Chiapas for the propagation of *Ceratozamia mirandae* Vovides, Pérez-Farr. & Iglesias and *Dioon merolae*, together with the El Triunfo Biosphere Reserve for the propagation of *C. matudae* Lundell, *Zamia soconuscensis* Schutzman, Vovides & Dehgan and the endangered palms *Chamaedorea quezalteca* Standl. & Steyerl. and *C. graminifolia* H. Wendl. Parallel ecological studies were carried out on the cycad species on these reserves (Pérez-Farrera *et al.* 2000, 2004, 2006; Pérez-Farrera & Vovides 2004). The Tehuacan-Cuicatlan

<sup>1</sup> The Ejido system was put in place in Mexico in the 1920s, during agrarian reform after the 1910 – 1920 Mexican Revolution. It assigns lands to local communities as common property.

Biosphere Reserve in Puebla initiated a nursery in the early to mid-1990s, employing local farmers at San Luis Atolotitlán for the propagation of the endemic *Dioon caputoi* De Luca, Sabato & Vázquez Torres. A population genetic study has also been completed for this species (Cabrera-Toledo *et al.* 2008). This nursery grows other native species such as a local 'mescal' agave (for alcohol production) and edible cacti (*Polaskia* spp.). The plants produced by this nursery are used in reforestation projects in collaboration with the Reserve authorities and as yet no cycad sales have occurred owing to administrative issues.

Independently, during the late 1990s, the Centro de Estudios para el Manejo Sustentable de los Recursos Naturales (CEMASREN), a non-governmental organisation (NGO) in Oaxaca, initiated a nursery in San Miguel Soyaltepec with a group of Mazatecan subsistence farmers for the propagation of *Dioon spinulosum* Dyer ex Eichl. They published a bilingual (Spanish and Mazatec) booklet on the conservation of this cycad. Recently, a population dynamic study assessed by us was carried out on two populations of this cycad at Soyaltepec (Salomé-Castañeda 2009). An additional nursery for *D. edule* was created in the Sierra Gorda biosphere reserve of Querétaro in the early 2000s. No sales data are available for these two nurseries.

### Plant reintroduction and further demographic studies

In an attempt to determine the minimum age that *Dioon edule* seedlings can be reintroduced back into the Monte Oscuro habitat, 300 seedlings produced in the Monte Oscuro nursery consisting of two-, four- and seven-year old plants were reintroduced into habitat during 1997 with follow-up monitoring and comparison with the cohorts in the nursery over 10 years. Mortality in the habitat was about 20% during the first year of monitoring. No mortality was recorded during subsequent years of monitoring and no measurable growth increment was reported in the reintroduced plants 10 years later, which confirmed the slow growth rate of this species reported by Vovides (1990). The reintroduced seven-year old class seedlings maintained a stem diameter of c. 4 cm with three leaves per crown, whereas the same age class in the nursery grown under conditions such as deeper soils, lack of competition and occasional watering during the dry season reached a stem diameter of 12 cm with 15 leaves per crown by 2005 and by 2009 a potted plant reached a stem diameter of 25 cm with 43 leaves. The plants in the nursery reached a reproductive age after 15 years for male plants and 17 years for female plants (Vovides 2008). During 1999 about 40 seedlings of *D. merolae* were reintroduced into the natural population in ejido

Andrés Quintanara Roo but follow up evaluation was not done.

The highest mortality for *Dioon edule* in the field was found to occur in seeds and seedlings (Vovides 1990; Octavio-Aguilar *et al.* 2008) being pre- and post-germination mortality due to seed loss and desiccation respectively during the first dry season. The population dynamics of *D. edule* were found to be a function of adult plant persistence with a stasis (L) value > 95%, suggesting that the conservation of adult plants is critical (Octavio-Aguilar *et al.* 2008). It is strongly recommended that decapitation of *D. edule* be stopped in Monte Oscuro as part of the management plan, in order to encourage recruitment and to strengthen population management. This, along with reintroduction of *D. edule* plants (especially reproductive young adults) at sites where populations of the cycad once existed should be encouraged in collaboration with the producers at Monte Oscuro.

## Marketing and other difficulties

### Training and support

During the process of training we found it essential to take into account the producers' methods of cultivation and the use of local, readily available materials. Basic grassroots horticultural practices must be repeated several times and encouragement given through continuous assessment, especially during the early years. Though the general layout of the nursery, management plan, infrastructure and methods of seed harvest and cultivation may be put forward by the assessors, local practices must also be taken into account for the day to day running of the nursery. For example, the producers in Chiapas prefer to work in their own backyards. This makes assessment more difficult since several backyards need to be visited. At Monte Oscuro this was not the case since one of the producers offered c. 0.4 ha of land for the nursery and it is managed by the men in the village. This was later divided into two nurseries where one member decided to work in his own back yard, but still maintains plants in the main nursery. The women ran the coastal nursery (Ciénega del Sur) in southern Veracruz cultivating *Zamia furfuracea* (Vovides *et al.* 2002), but this nursery has since been abandoned. Naturally, training in basic techniques was much easier at collective nurseries where all members were present. An illustrated booklet on seed harvest, sowing and cultivation of cycads was produced aimed at technicians and producers (Pérez-Farrera & Vovides 1997).

### Sales

Plant sales have been, and still are, sporadic and inconsistent, this being due to both the lack of

marketing expertise among the assessors and a marketing project that was set up late. Marketing research was reversed, because a decision was taken to set up nurseries first and then to market plants later. This mistake has resulted in a high level of dropouts during the early years of establishment of the Monte Oscuro nursery, from 24 members at the beginning down to five by 2001 (Vovides *et al.* 2002) and to three by 2009 owing to the death of two elderly members. The marketing problem was partially addressed by a three-year GTZ-German-Mexican technical collaboration project in 1995, followed by a two-year GTZ-ProTrade private partnership project that resulted in two shipments of nursery-grown *Dioon edule* and *Zamia furfuracea* to be presented at two consecutive horticultural exhibitions at Essen, Germany during 1999 and 2000. However, at that time the plants from the Chiapas nursery were still too small for marketing. The export logistics and paperwork were covered by a small agency set up by the project, which dealt with the CITES, phytosanitary and export paperwork as well as transport logistics during the duration of the project. This export venture was not successful owing to fierce competition in the international horticultural trade, especially with the faster growing and commercially produced cycad *Cycas revoluta*. Apparently the horticultural industry, in this case, was insensitive to the conservation message of the project, and we feel that the wrong horticultural market was approached.

However, modest exports to the USA, together with domestic sales, have been more encouraging. In the case of the Monte Oscuro nursery, sales points at botanic garden shops (UNAM botanic garden at Mexico City and the JBC), a municipal garden centre at Xalapa and attendance at town fairs and local exhibitions have been encouraging for the sale of *Dioon edule* and *Zamia furfuracea* (amounting to c. US\$1280) (Fig. 2). Two important sales of *D. edule* were made between 2005 – 2007, one to the Xalapa municipal authorities and the other to an urban developer encouraged to use native flora for municipal gardens and landscaping (Fig. 3). The plants were medium-sized specimens between 12 – 17 years old with crowns of 10 – 20 leaves. In the case of the Chiapas nurseries the export of the cycad *Ceratozamia matudae*, *C. mirandae*, *Dioon merolae* and *Zamia soconuscensis* occurred only between 1998 – 2000 and only when the second author personally dealt with the export paperwork, CITES and transport logisitcs. The four species exported to the USA in 1998 were three-year old seedlings (400 in total) that sold for c. US\$7 each. This was very encouraging, since these species are rare on the market in comparison to the c. US\$2 for equivalent seedlings of *D. edule*. In 1999, 50 *D. merolae* seedlings were sold during the Mexican National Botanic Gardens Conference held at Tuxtla Gutiérrez, Chiapas, and in 2000, 70 seedlings of the four species were sold during an

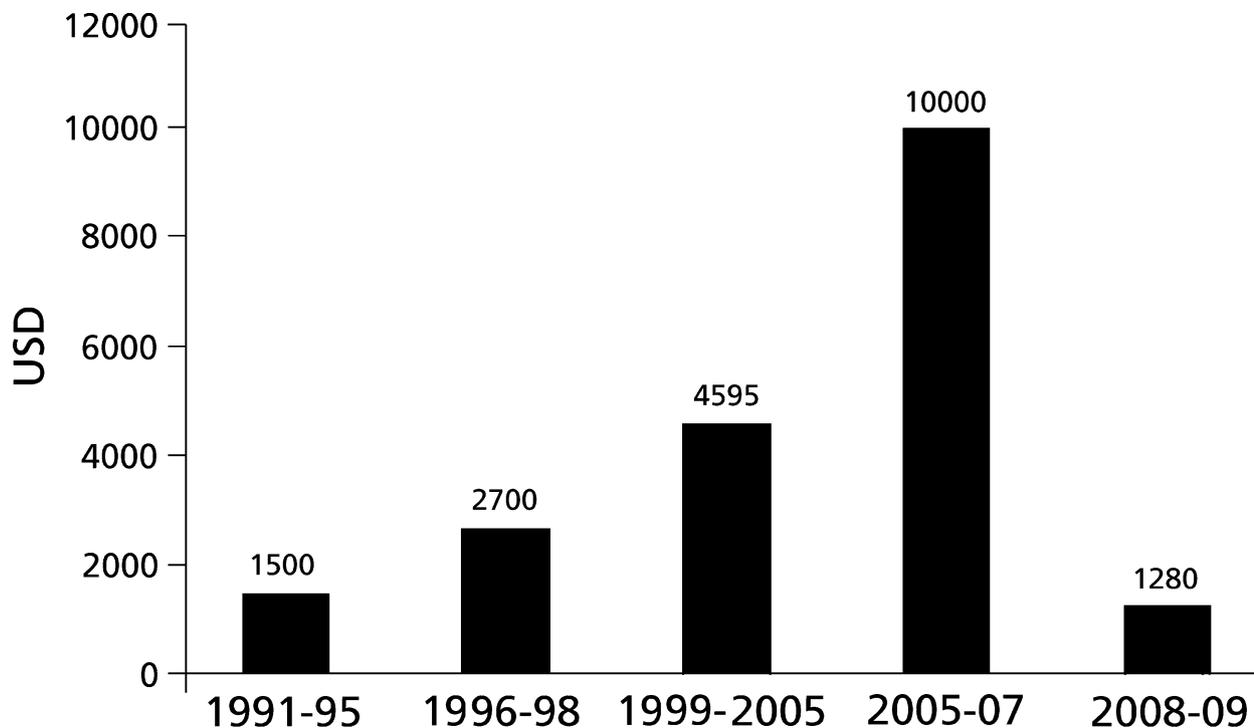


Fig. 2. Sales figures 1991 – 2009 (US\$) for *Dioon edule* from Monte Oscuro. Note time intervals not even.



Fig. 3. Nursery grown *Dioon edule* plants used in municipal landscaping and road verges in Xalapa, Veracruz.

international exhibition in the World Trade Centre in Mexico City (Fig. 4). For further details on the Chiapas Biosphere reserve nurseries see Pérez-Farrera (2008).

Plant sales, though not optimal, have been encouraging to the producers who are convinced that conservation through propagation can work as an additional activity to their normal farming practices.

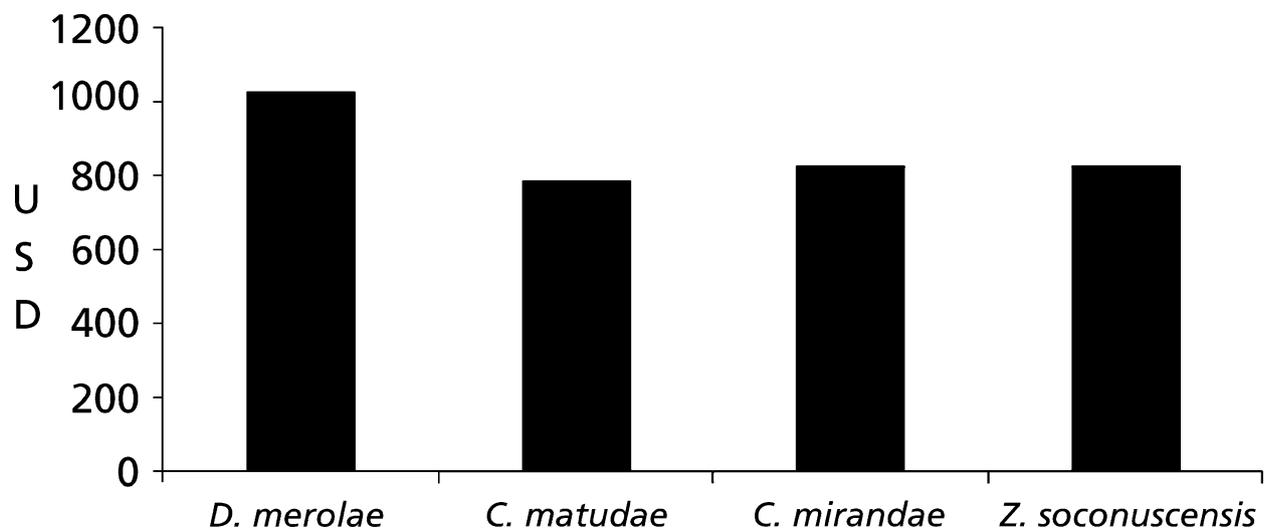


Fig. 4. Sales figures in USD from 2008 to 2000 for four cycad species from the Chiapas nurseries.

Poaching has largely stopped on the nurseries' lands but competition from poachers who remove plants from other localities still occurs owing to inefficient law enforcement. The cycads' *in situ* nurseries are not labour intensive and since the plants are slow growing and long-lived, their value increases as they get older, and temporary abandoning of the plants does not appear to affect them. This has been a trade-off for the slow markets, since sales can improve at much later dates.

#### Assessment of success/failures

One of the main reasons for the relative success and persistence of the Monte Oscuro and Chiapas nurseries is that the project was kept small and we could still keep contact with the producers on a voluntary basis at times when finance was low or non-existent. A similar project in Costa Rica, using *Zamia skinneri* Warz. ex D. Dietr, failed. This was a relatively larger, well funded five year project aimed at a regional level addressing several issues in addition to cycad propagation, but when funds dried up the technicians/assessors pulled out (Ocampo pers. comm.).

Because of the remote location of some of the nurseries, especially those in the Sepultura Biosphere Reserve of Chiapas, Tres Picos, Nueva independencia, La Sombra de la Selva and Cerro Polo in the El Triunfo Reserve, the producers experienced difficulties keeping their paperwork and permit renewals up to date, as well as maintaining links with local markets. These nurseries became seriously overdue in their permit renewal and needed to re-register years later. In our opinion, the paperwork involved in registration and follow-up annual reports is unnecessarily complex, cumbersome and inefficient. The farmers find these procedures daunting and need much assistance. Such problems, coupled with poor marketing due to a lack of marketing expertise and poor access to transport routes, have greatly hampered sales. The nurseries have the plants and there are potential buyers, but getting the plants to the buyers has been difficult. A meeting to address this issue took place during November 2006 in Tuxtla Gutierrez, Chiapas, between the assessors, producers and representatives from the environmental authorities. After further meetings it was agreed that producers should be given assistance



**Fig. 5.** Rescued *Dioon edule* plants sheltered at the Monte Oscuro nursery from affected habitat during the Xalapa bypass construction, Sr. Concepción Díaz-Villa, nursery owner standing by large adult cycad.

by providing a facilitator to help with paperwork and by financing small projects to activate marketing. The Sepultura Biosphere authority is providing this assistance as well as planning a small agency for marketing.

It is clear that establishment of marketing techniques, together with the collaboration of horticultural specialists and facilitators for permits and other paperwork to work closely with the producers, is essential for the long-term success of the project. The registration and permit requirements demanded by the authorities need to be drastically reduced and simplified.

The need for further training and management skills in the nursery to produce quality plants that meet the buyers' specifications is ever present. Horticultural practices based in botanic gardens should be developed and transferred to the producers.

### Cultivation trials at the Jardín Botánico Francisco Javier Clavijero

At germination most cycads produce a vigorous taproot that enables rapid and effective anchoring to the substrate, as well as more efficient water foraging. However, under cultivation this makes handling of most cycads (especially *Dioon* seedlings) in pots and containers difficult, where disproportionately large pots are required to accommodate the long taproots that encircle the bottom of the pot or exit through the drainage hole. This makes frequent transplanting necessary. Dehgan & Johnson (1987) carried out principal root excision on *Zamia* and *Dioon* seedlings and application of IBA (indole- $\beta$ -butyric acid) that resulted in regeneration of up to three primary roots followed by vigorous growth. We conducted similar experiments but instead of treating with growth regulators we inoculated with the native mycorrhiza *Glomus ambisporum* Smith & Schenck, previously isolated from *Dioon* seedlings grown in native soil. A notable and significant increase in fresh weight and vigour was observed in the treatment seedlings compared to the untreated controls (Vovides *et al.* *in press*). This technique can be simplified and applied by producers to increase growth rates of their seedlings, resulting in faster growth and better quality plants that can be managed more efficiently in pots and containers.

### UMA nurseries as potential rescue centres

Since the general law on ecological equilibrium and environmental protection (Ley General del Equilibrio Ecológico y la Protección al Ambiente) came into force in 1988, the Mexican environmental authorities now require environmental impact studies to be done before any civil engineering projects such as roads, hydroelectric dams, urban developments etc are approved. A number of consultant agencies have been

created to provide such impact studies and a number of these studies require that affected flora and fauna, especially protected species listed in the Mexican Norm (Anon. 1994), be rescued, transplanted and reintroduced into areas not affected by the engineering project. An example is the Zimapan hydroelectric project, where the flora of the Rio Moctezuma valley was affected (Calahorra *et al.* 2006). A number of large barrel cacti (*Echinocactus grusonii* Hildm.) and other species were rescued and moved into areas where the eventual water level of the reservoir would not reach them. Some specimens were also donated to botanic gardens.

The UMA nurseries have a potential role in plant relocation and shelter for rescued plants. The recent Xalapa bypass project has affected cloud forest and tropical dry forest floras and the cycads rescued from the affected areas of these forests, *Ceratozamia mexicana* and *Dioon edule* respectively, are temporarily located in two local UMAs (Tlachinola and Monte Oscuro) that specialise in these species. The expertise in these nurseries now exists and optimal care of the plants can be given that will benefit the producers through additional income from space rental and care (Fig. 5). These plants are inventoried and intended to be reintroduced back into habitat, especially for landscaping the bypass highway verges. Alternatively the UMAs can provide nursery-grown plants for later verge landscaping and reintroduction. However, this venture is too recent for any objective evaluation of its success and appears to be rife with administrative hurdles that need to be dealt with.

### Conclusions

That species conservation can be linked with the economic interests of local people has generally been demonstrated and producers support the concept of rural nurseries despite erratic sales. We believe that this concept has been relatively successful in Mexico because nurseries were kept small and continuity could be achieved when funds were low. The nursery concept has been implemented in other countries such as Panama, China and South Africa, although with varying results. Thus a local endeavour has become globally-based upon sound principles and implementation. The following points should be considered in the implementation of similar ventures:

1. Previous ecological and propagation studies are important, as well as long-term monitoring of the managed habitats.
2. Early marketing studies should be done and links developed with potential markets.
3. Continuous assessment of the producers, taking into

consideration local practices as well as locally developed techniques. 'Belief' in the project on the part of the assessors is imperative.

4. The technical team should be multidisciplinary and should include, not only botanic garden horticulturists, but also sociologists and marketing experts.
5. Close links with the relevant authorities are essential, especially in remote locations where a facilitator should be provided to deal with the necessary paperwork for permit renewal, reports, phytosanitary and CITES certificates.
6. Long term funding for small local projects is preferable to short term funding of large regional projects.

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