CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Seventeenth meeting of the Plants Committee
Geneva (Switzerland), 15-19 April 2008

Non-detriment findings

Timber species and medicinal plants

# FINAL REPORT ON THE STUDY ON ABUNDANCE, DISTRIBUTION AND CONSERVATION STATUS OF *GUAIACUM SANCTUM* L. IN MEXICO

1. This document has been submitted by the Scientific Authority of Mexico.

2. The report was prepared by the National Commission for the Knowledge and Use of Biodiversity (*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad* - CONABIO), Mexico's CITES Scientific Authority, on the basis of reports from the *Centro de Investigaciones en Ecosistemas* (CIECO) of the National Autonomous University of Mexico (UNAM), the institution entrusted with carrying out the study on "Abundance, distribution and conservation status of *Guaiacum sanctum* L. in Mexico".

## Background

3. At the 12th meeting the Conference of the Parties (CoP12, Santiago, 2002), the Parties adopted a proposal to include *Guaiacum* spp. in Appendix II of the Convention, and Decision 11.114 (Rev. CoP12) relating to *Guaiacum* spp. as follows:

   ***Directed to the Plants Committee***

   *The Plants Committee shall assess the status of* Guaiacum *species in the wild, the status in trade and threats to the species.*

4. Following Decision 11.114 (Rev. CoP12) and previous discussions during the 11th and 12th meetings of the Plants Committee, Mexico developed a project to evaluate the status of wild populations of *G. sanctum* in Mexico in order to determine the conservation status and availability of the species. This aimed to provide a basis for determining the viability of harvesting wild populations in a sustainable manner in compliance with Article IV of the Convention.

5. During PC13, PC14 and PC15, Mexico presented progress reports of the Mexican study that included preliminary results on potential distribution, rapid population assessments of the species in the Yucatan Peninsula, diagnostic of types of vegetation and habitat, allometry comparisons between *Guaiacum sanctum* and *G. coulteri*, interviews of local people in the surveyed areas and preliminary recommendations. Information on the actions taken through a collaborative effort among scientific, administrative and law enforcement authorities in Mexico has also been included in the different reports (documents PC13 Inf. 2, PC14 Doc. 6.3, PC14 Inf. 1, PC15 Doc. 23).

6. The final report (presented as an Annex to this document) represents a comprehensive summary of the most relevant findings and recommendations derived from the study including funding sources, and other relevant actions related to the study. These were compiled through a collaborative effort among scientific, administrative and law enforcement authorities in Mexico.

Summary of the main results and recommendations of the study

7. The study concluded that *Guaiacum sanctum*, locally known as Guayacan, is widely distributed in the south-east of Mexico, with the most abundant populations being found in the States of Campeche and Quintana Roo, although it can also be found in Oaxaca and Chiapas.

8. *Guaiacum sanctum* has a discontinuous distribution occurring in tropical sub-deciduous forests, both in hills and plains, which are not subject to periodic floods, especially in the state of Campeche. According to Martinez and Galindo (2002), this type of forest is widely distributed in one of the regions in Campeche. In these sites, the density can be of more than 200 trees/ha with DBH (Diameter at Brest Height) > 10 cm. A significant change in land use in the state of Oaxaca and even more in Chiapas, seems to place these populations in high risk of extinction. Studies on restoration of the species and the forest should be considered.

9. It seems that the more important risk that *G. sanctum* populations face is land use change, from tropical deciduous forests to agriculture or cattle ranching systems.

10. *Guaiacum sanctum* trees grow very slowly, close to an average of 8 cm in height annually when they are < 150 cm in height, and 1.8 mm in trunk diameter for trees with DBH > 1 cm. The species is considered long-lived with a life expectancy of more than 320 years.

11. Guayacan's first reproduction occurs between 30 and 40 years of age, and reproduction and fecundity probabilities increase significantly with the size of the trees.

12. The highest natural mortality rates of *G. sanctum* occur during the seed, seedling and juvenile (< 100 cm height) stages, while the lowest occur in pre-adult (< 5 cm DBH).

13. The results of demography and population dynamics studies, suggest that both Calakmul Biosphere Reserve (CBR) (an unmanaged area) and Ejido Pich Forest Reserve (EPFR) (a managed area subject to commercial logging) represent areas with relatively abundant populations of the species.

14. Important demographic differences were found between populations. CBR showed lower rates of mortality, growth and fecundity than EPFR. Matrix analyses suggest that both populations are growing, and if vital rates were maintained constant, CBR population would have a significantly higher population growth rate than EPFR. These differences show the flexibility of *G. sanctum* life history attributes. This flexibility may be due to different local environmental conditions, intrinsic population properties (genetic attributes), management effects in EPFR or a combination of these factors.

15. Elasticity analyses suggest that adult tree survival (DBH > 1 cm) is the most important factor influencing population growth rate, while changes in individual growth and fecundity are relatively marginal.

16. Computer simulations in EPFR suggest that selective logging of commercial trees have a low or almost negligible impact on the population growth rate. Nevertheless, it shows that the population is very sensitive to mortality of small adult trees (1-25 cm DBH). For this reason, it is crucial to minimize mortality of these classes during the extraction process in order to achieve a sustainable harvest of commercial trees.

17. The model suggests that, if current logging practices are maintained constant through time, this would bring population growth rate close to demographic equilibrium ($\lambda = 1.007$). From a demographic perspective, this kind of forest management is sustainable. Nevertheless, reduction of impact on small trees through breaching has to be secured (planning for optimal extraction routes), as well as optimal harvest frequency.

18. Simulation showed that resting periods (from one harvesting season to another) of 15 or more years are fundamental for sustainable management of *Guaiacum sanctum* populations in EPFR.

19. Long-term monitoring of the studied populations and assessment of additional localities are desirable. Considering that *G. sanctum* is a long-lived species and that the tendency and patterns found in this study are subject to modifications due to variability in climatic and other biotic factors, consideration of temporal and spatial variations is also important.

Other studies

20. In addition to the population dynamic study, CONABIO is coordinating a project related to genetic diversity estimates, crossing-over rates, inbreeding, and gene flow between populations for areas with different conservation conditions. Results of this project will be relevant to identify important conservation areas for the species.

Management of the species in Mexico

21. The findings confirm that the species is not at risk of extinction, and sustainable harvest of the species can be done if based on extraction procedures that favour recruitment of young trees and low extraction levels are maintained with relatively wide time-frames.

22. Based on the results of the study, CONABIO organized a national workshop (see more details in the Annex) with the participation of governmental agencies, scientists, and industry, to review the status of wild populations, and relevant management and commercial aspects, in order to formulate recommendations for a sustainable management of the species in Mexico.

23. Current non-detriment findings for *Guaiacum sanctum* are formulated on the basis of the information and recommendations provided by the study. This means that the management programmes required for the extraction of the species have been analysed by the Scientific Authority taking these recommendations into account. Recently, two management programmes have been evaluated by CONABIO.

Conclusion

24. In order to comply with Decision 11.114 (Rev. CoP12) , México presents this report to the CITES Plants Committee as a contribution to its task to assess the status of *Guaiacum* species in the wild, the status in trade and threats to the species. The report provides elements needed to formulate non-detriment findings for the exportation of the *Guaiacum sanctum* from Mexico and can be used as a reference for studies and NDFs in other exporting countries. With this report Mexico concludes the assessment of the species in relation to Decision 11.114 (Rev. CoP12).

25. Mexico wishes to thank the U.S. Forest Service, the German Government and the CITES Secretariat for their kind funding and support to this study.

# FINAL REPORT ON THE STUDY ON ABUNDANCE, DISTRIBUTION AND CONSERVATION STATUS OF *GUAIACUM SANCTUM* L. IN MEXICO

## Objectives

The study aimed to determine current distribution, abundance, and population dynamics of *Guaiacum sanctum* in Mexico to determine its conservation status and availability. Thus it intended to provide the basis to determine the viability to make use of wild populations sustainably, considering the alteration degree of the habitat. Also to produce the information needed to define proper management recommendations and to secure sustainable commercial exportation of the species from Mexico. The identification of priority conservation areas was part of the project. In addition, the evaluation considered some aspects of the natural history and habitat condition (well preserved, fragmented, degraded). All this information would be used to develop proper indicators to evaluate the conservation status and population viability of wild populations in Mexico.

## Research team and contributors

The study was developed by a group of scientists from the *Centro de Investigaciones en Ecosistemas* (CIECO) of the National University of Mexico (UNAM) Campus Morelia, leaded by Dr. Miguel Martinez Ramos, and with the support of CONABIO, who was responsible for the coordination and administration of the project, as well as for co-financing part of it, and therefore kept periodic communication with the researchers and made periodic evaluations of the reports, assisting them with available resources (e.g. information systems: species localities database).

a) Research leader and general coordination: Dr. Miguel Martínez Ramos.
b) GARP & SIG: Dr. Gerardo Bocco, Dr. Alfredo Cuarón, and M. en C. Leonel López Toledo, Dr. Enrique Martínez-Meyer (IB-UNAM).
c) Demography and population dynamics: Dr. Miguel Martínez and M. en C. Leonel López Toledo
d) Plant communities: Dr. Guillermo Ibarra and Dr. Diego Pérez.
e) Population genetics: Dr. Ken Oyama.
f) Reproductive Biology: Dr. Mauricio Quesada.

## Funding

The total cost of the project was 35,518 USD (c.a. 382,500 Mexican Pesos) and was covered by national and foreign institutions: CONABIO: 11,000 USD (c.a. 120,085 Mexican Pesos); U.S. Forest Service: 15,000.00 USD (c.a. 155,250 Mexican Pesos); German Government through the CITES Secretariat 9,518.00 USD (c.a. 107,165.00 Mexican Pesos).

## Study area

Based on potential distribution maps produced by CONABIO, the following sampling areas, characterised with a high probability to find *Guaiacum sanctum* populations, were selected: Tehuantepec Isthmus (Oaxaca); La Angostura (Chiapas); Calakmul Biosphere Reserve, Bosque Modelo, Cobá, and localities close to Escárcega (Campeche); Puerto Morelos region and Dzibilchaltum Natural Reserve (Yucatán); and Sian Ka'an Biosphere Reserve (Quintana Roo).

After the rapid field assessment survey in those localities, two additional areas in Campeche: Calakmul Biosphere Reserve (CBR) and Ejido Pich Forest Reserve (EPFR) were selected to study the demography and dynamic of managed and un-managed populations. CBR includes around 17 vegetation types, of which *Guaiacum* forest represents an important percentage of the whole area (Martínez & Galindo 2002). EPFR is a relatively forested area, adjacent to the Ejido Chencoh forest reserve, Balam-Kin Reserve (previously Ejido Dzibalchen) and Balam-Ku Reserve.

Methods

**Current distribution and abundance models:** Using information from herbarium specimens' records, provided by the scientific collections database of CONABIO's National Biodiversity Information System (SNIB), regional literature, experts, local informers and cartographic material, a potential map of the current distribution was constructed using Desktop GARP (Genetic Algorithm for Rule-set Production, Stockwell and Noble 1992).

During October 2003 and May 2004 eleven rapid field assessments along the distribution area were performed. A population survey was made for each selected locality according to the following protocol: Ten 50 x 2 m plots were sampled totalling 0.1 ha at each site. The first plot was randomly established and the other nine were parallel to a 50 m distance. Height and diameter at breast height (DBH) for all the *G. sanctum* individuals > 150 cm and > 1 cm DBH rooted within the plot were recorded. The number of individuals < 150 cm were registered in three different height categories i) 5- 50 cm 2) 50.1-100 cm iii) 100.1-149.9 cm. Canopy height openness (measured with a densitometer) and slope were recorded every ten meters at each plot, while ground depth was recorded at the centre of each plot. With this information, population structure and density were estimated for each locality. Anthropogenic perturbation such as livestock presence, agriculture and forestry was registered. Community of trees > 10 cm DBH at each site was described in terms of composition, diversity of species and basal area. Within the plots taxonomic identity, height and DBH measurements were recorded for every tree ≥10 cm of DBH. Taxonomic identity was completed with help of experts and herbarium specimens.

Based on rapid field assessments, interviews, and direct observations, abundance was estimated to every visited site. This abundance estimation was used in a "moving average" interpolation to calculate areas of different abundance along the range of distribution. Due to the natural non-homogeneous distribution of the species, the map was further refined using a vegetation map modified by CONABIO, confining the potential distribution of the species to dry and semidry forests.

**Demography and population dynamics:** The study of demography and population dynamics was carried out at two localities in Campeche in 1ha permanent plots at each site, subdivided in ½ ha plots separated each other for 500 m. These populations were a protected population in CBR and a recently managed (harvesting season: 2003) population in EPFR. Demographic patterns (survival, growth and fecundity rates) and the population dynamics (population growth rate and elasticity analysis) were followed at each population according to criteria established by Caswell (2000). All individuals of *G. sanctum* taller or equal to 1.5 m height and DBH ≥ 1 cm were identified, mapped and tagged in the plots and their height or/and diameter at breast height (DBH) was recorded. This measurement was marked with permanent paint to allow repeated measurements at the same height for growth estimation. All individuals with heights shorter than 1.5 m were mapped, tagged and their height and diameter at ground level were recorded on 2 x 2 m subplots, randomly spread over the plot. All tagged individuals were censed for survival, height and DBH growth one year after the initial census, and new recruits in the plots and subplots were tagged and measured. For reproductive individuals, floral, fruiting phenology and seed production per tree was estimated.

Results

**Distribution:** Potential distribution maps (to define ecological niches) were elaborated using Desktop GARP, based on 200 registers (including 137 presence and 63 absence points for the species) and 11 environmental layers, including elevation, temperature (max. and min.), rainfall, slope, soil, and potential vegetation The probable niches distribution maps resulted from 30 iterations of the algorithm and then refined using distribution probabilities, eco-regions, bio-geographic provinces and recent vegetation type maps. (see Figure 1).

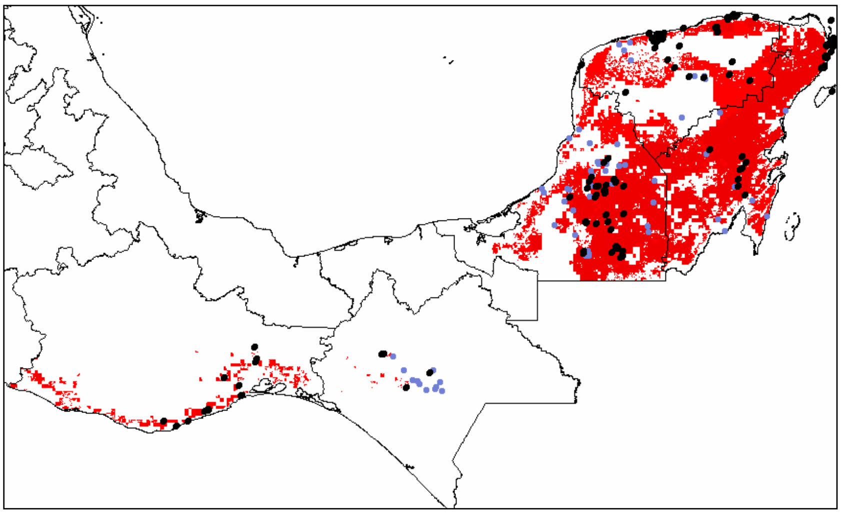

**Figure 1** ***Guaiacum sanctum*** herbarium specimens' records and potential distribution map using GARP. Light blue dots represent absence of the species, while black dots represent presence of it.

The determination of the field sampling sites for both species was based on this maps and a number of survey routes were established in order to access locations with the highest probability of finding populations of *Guaiacum sanctum*.

**Abundance model:** The most important distribution area of the species lies within the central and south region of Campeche. Other areas where the species can be found are the northern and central parts of the Yucatan Peninsula, central Quintana Roo (in particular within Sian Ka'an Biosphere Reserve), and the Tehuantepec Isthmus. The Central Depression of Chiapas, showed very low abundance and populations might be in risk of extinction (Figure 2). Areas with different management and levels of protection were identified (Figures 3 and 4).

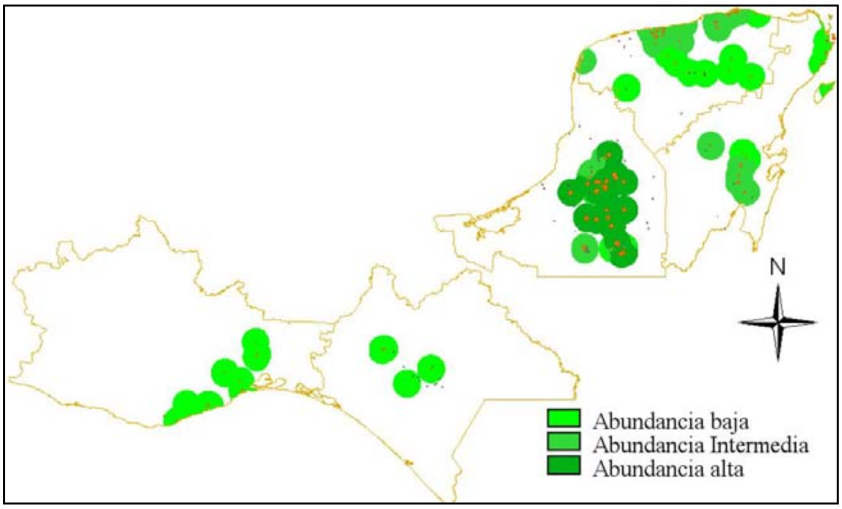


**Figure 2.** ***Guaiacum sanctum*** **Abundance model.** Low abundance: < 30 individuals/ha; Medium abundance: < 200 individuals/ha; High abundance: > 200 individuals/ha (only individuals ≥ 10 cm DAP are considered here).

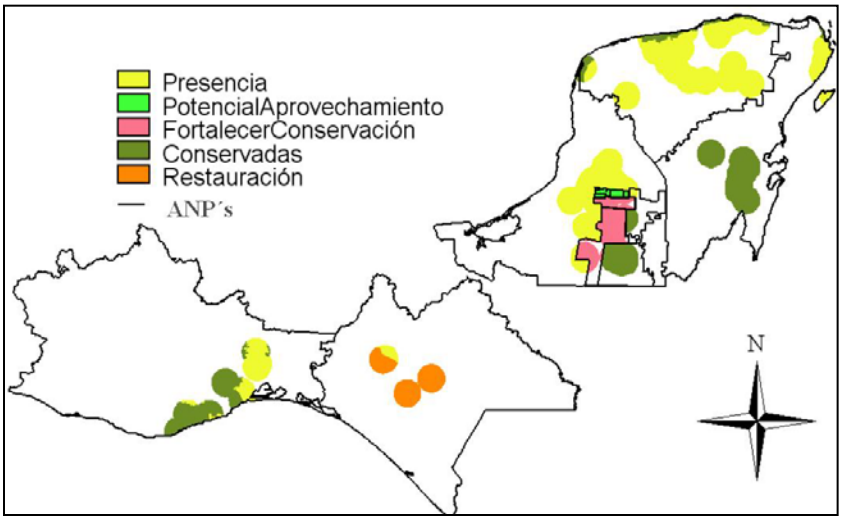


**Figure 3. Identified areas with different land uses and levels of protection and management.** The areas in yellow represents the regions where the species can be found, in light green the potential use areas, in pink the areas that would benefit from additional conservation measures, in orange the areas where the species may be in risk of extinction and would benefit from some restoration measures and finally the lines identify the polygons of the current natural protected areas.

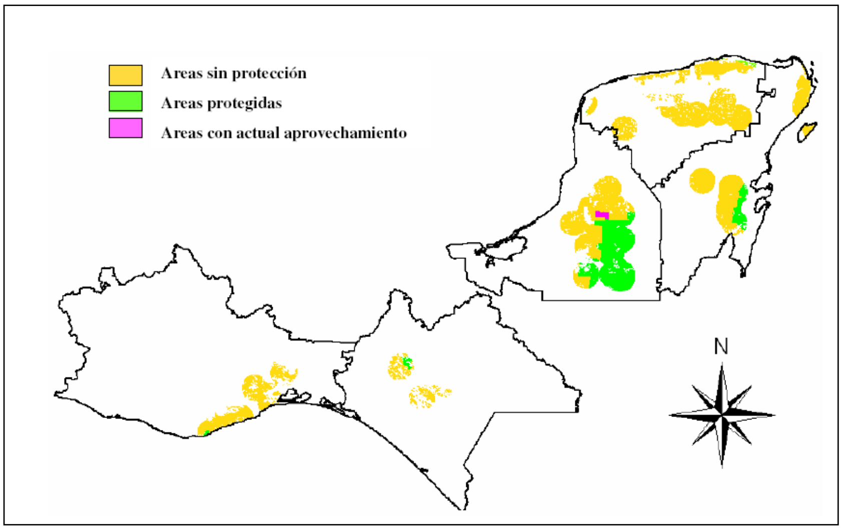


**Figure 4.** Areas under protection and where current management (commercial logging) of *Guaiacum sanctum* occurs.

<u>Demography and population dynamics</u>

**Population structure:** For each population a sample of 50 individuals (minimum) were marked in each life cycle phase. Results show high abundance of seedlings and young trees, suggesting that both populations have a good regeneration potential and that germination and development requirements for first life stages are not very strict, nevertheless transition to later stages seems to be characterised by important mortality events (see Table 1 and Figure 5).

**Table 2.** Density (individuals/hectare)

| Life stage/Classes | CBR | % | EPFR | % |
|---|---|---|---|---|
| Seedlings (<50 cm height) | 2,266 (207) | 65.28 | 53,058 (1475) | 94.49 |
| Small trees (51-150 cm height) | 930 (85) | 26.79 | 1,942 (54) | 3.45 |
| Trees 1 (DBH 1-10 cm) | (246) | 7.08 | (860) | 1.53 |
| Trees 2 (DBH > 10 cm) | (29) | 0.83 | (287) | 0.51 |
| TOTAL | 3,471 (567) | | 56,147 (2676) | |

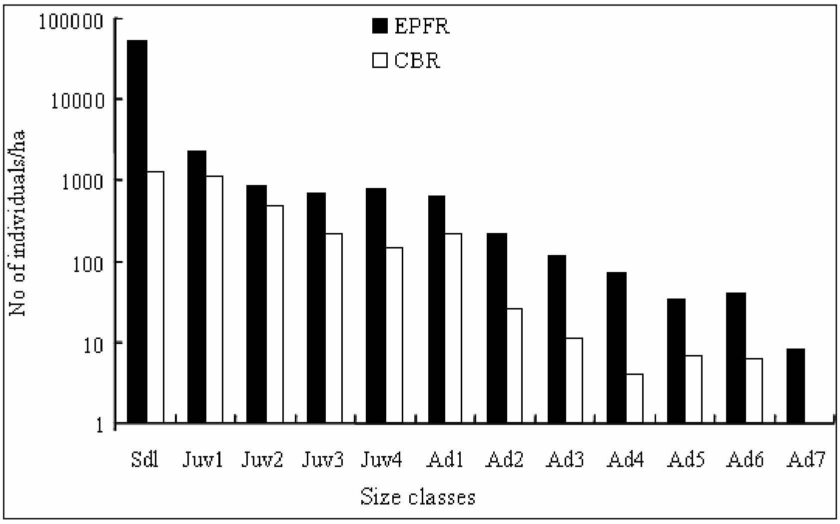


**Figure 5.** *Guaiacum sanctum* population structure in two permanent sampling areas within CBR and EPFR; it shows only the trees with DBH ≥ 1 cm.

**Mortality:** Overall, mortality rates declined with increasing tree size (Figure 6). Over a one year period, mortality of adult trees in both populations, was very low and did not vary between them or between size classes. In contrast, seedlings and juveniles exhibited higher mortality rates at the exploited site, but "seedlings" was the size class with the highest mortality in both populations (Figure 6).

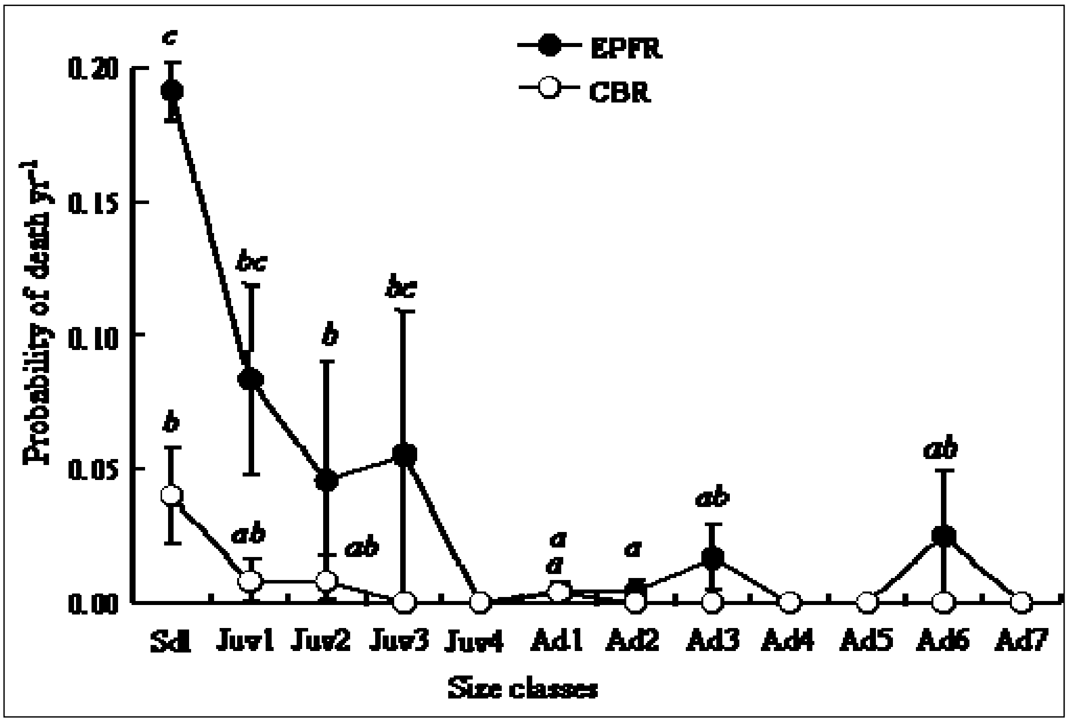


**Figure 6.** Mortality rates of *Guaiacum sanctum* in both populations.

**Growth:** Growth in height, was in general higher for juveniles than for seedlings at both sites with the exception of Juv-1 and Juv-2 at CBR. Seedlings grew equally at the exploited and unexploited site, but taller juveniles (juv-3 and juv-4) grew faster in the exploited site. In general DBH growth rates in adults were very slow in both sites, although mean growth rates were significantly greater at EPFR than CBR for trees of 1-4.9 cm (Ad1) and 25-34.9 cm (Ad6) DBH.

**Growth-age estimations:** The growth trajectories for *Guaiacum sanctum* based in the annual DBH increase for the different life stages (Lieberman and Lieberman 1985), estimated that a mean of 70 years are required at both sites for a seedling to reach 1 cm DBH. In addition 320 yr at EPFR and 210 yr at CBR are required for an individual of 1 cm DBH to reach the largest DBH. Therefore, adding the 70 years prior to 1 cm DBH, gives an estimated longevity around 280-390 years at Central Yucatan Peninsula (Figure 7).

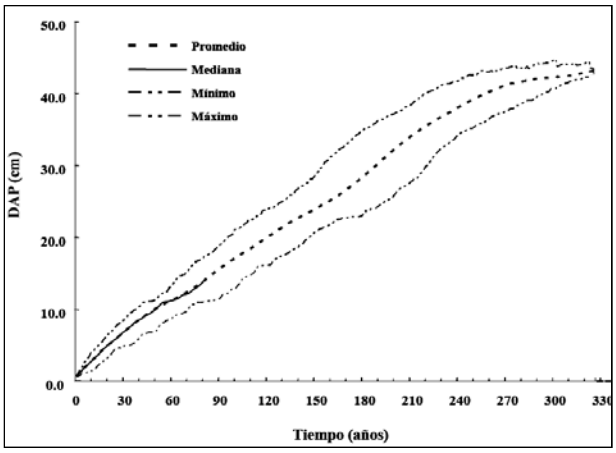


**Figure 7.** *Guaiacum sanctum* Growth- age estimations.

**Reproduction:** Flowering occurs between February and April, with a peak before February, while fruit production occurs between April and May, with a peak of fruiting individuals in May; and mature fruits are present in June. 35% of the trees flowered in EPFR, compared to less than 8% in CBR.

Fecundity (number of seeds produced by each tree) showed an exponential increase with the size of the trees, starting with approximately 10 seeds/tree in individuals from 1 to 4.9 cm in DBH, up to 10,000 in trees with DBH>35cm. In both populations trees with DBH ≥ 25 cm contributed with more than 60% of seed production. It was estimated that the first reproduction occurs between 30 and 40 years of age, but with a very low seed production. For CBR, age at first reproduction was estimated at 50 years, 20 years more than EPFR (Figure 8).

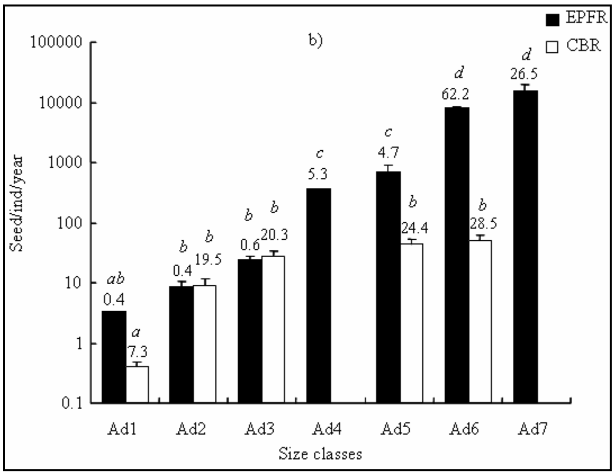


**Figure 8.** Fecundity (annual average seed production for individuals) variation in relation to DBH (cm) classes for the two populations studied. Numbers represent average number of seeds produced by individuals on every one of the seven size classes.

**Life cycle:** In CBR mortality rates for every life stage are notably lower than in EPFR, this is particularly evident in early life stages, such as seedlings and juveniles. Seedling mortality seems to be positively correlated to canopy openness. Nevertheless, it was found that high light intensities (e.g. large clearings) could prevent seedlings from growing. Apparently there is an optimal light incidence (medium), between 8% and 12% of canopy openness, that seems to favour seed germination and/or establishment, as well as seedling survival and growth. There is also a clear relation of topography and flooding with the presence of *G. sanctum*. The study concluded that the species does not have a proper development in flat areas (most probably because these are flooded most of the year), both localities show slopes between 5.6° and 5.8° in average.

EPFR population presented significantly higher density values for most life stages. Annual probability of remaining in the same life stage was higher in CBR as well, which reflects lower mortality rates. Transition from seed to seedling was one order of magnitude higher in CBR, while in EPFR more than 90% of the seeds were lost due to different reasons. Transition probabilities from seedling to juvenile was four times faster in CBR as well, while transition probabilities between adult life stages were in general slower than those registered for EPFR population. Based on all the information presented above, life cycle diagrams were developed (Figures 9 and 10). These diagrams show the flow of individuals through the different life stages. Circles represent the different life stages and their size is related to the density found in each site per hectare. Rectangles represent the percentage of annual seed production per tree in each life stage.

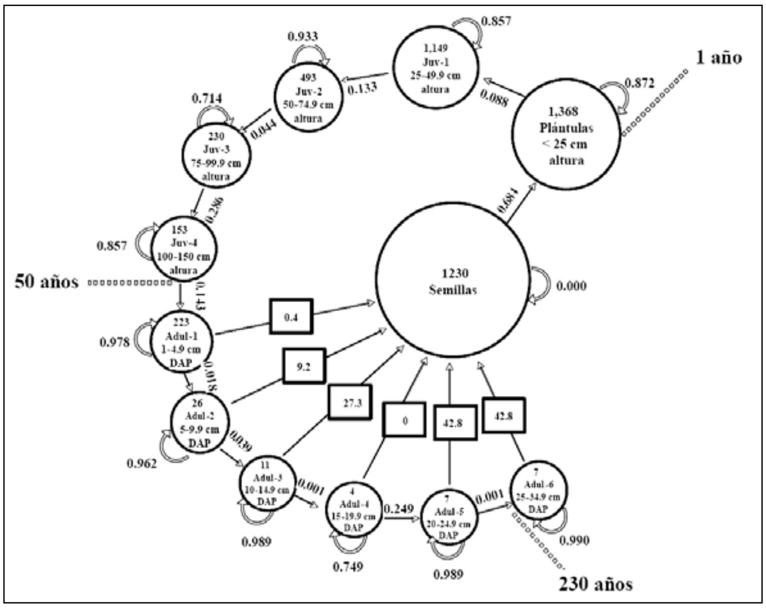

**Figure 9.**CBR life cycle diagram (the numbers over the arrows and between the circles represents the annual transition probability between life stages/classes).

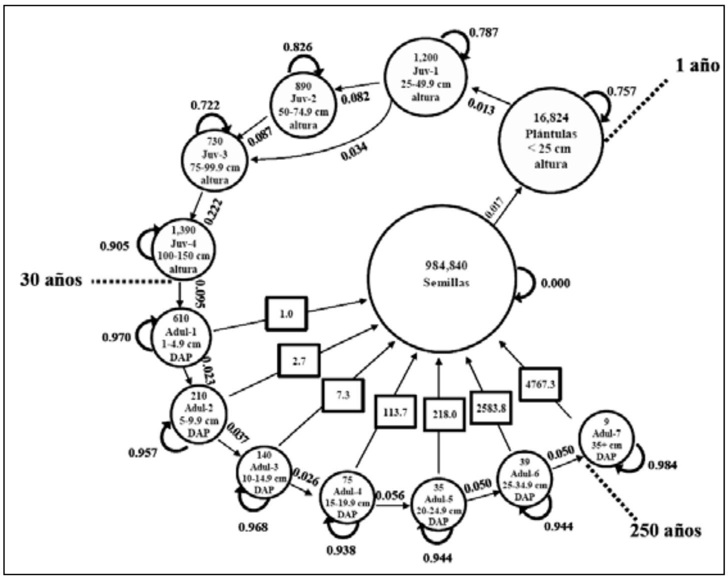

**Figure 10.** EPFR life cycle diagram (the numbers over the arrows and between the circles represents the annual transition probability between life stages/classes).

**Population dynamics and modelling of harvesting scenarios:** A matrix model was generated for the species assuming populations are stable (growth, mortality and fecundity constant through the time). After a defined number of iterations of the model, the future size structure was projected, with different extraction percentages and recruitment values. The model suggest that a cut (harvest) rate of 50% of the trees with DBH ≥35cm once every 10 years can maintain the population in equilibrium if recruitment is guaranteed.

A computer-based simulation was carried out to explore the possible results of different (hypothetical) selective logging scenarios of Guaiacum populations. Based on elasticity analysis it was determined that the most important life stages for the population growth rate (λ) are adults between 1-25 cm DBH, even more important than Adults > 35 cm DBH. This simulation does not consider aspects such dry years, severe storms, pests and diseases, and specially germination of seeds and survival of pre-adults and adult trees.

Based on these simulations, it can be concluded that the extraction of commercial trees may not have a significant impact on the population growth rate. For example, for any extraction percentage of commercial trees (20%-100%), if small trees are left standing, the model suggest that 8 will reduce only around 0.7% and 1.1% with regards to its original value in the absence of commercial logging. On the other hand, if no commercial trees were extracted, but a sustained annual extraction of small trees (above 9%) was carried out, 8 would go below 1 and the population could decline becoming extinct in the long term. This means that commercial logging for the species must take into consideration a maximum extraction (i.e. for breaching) of not more than 4% of small trees (DBH 1-25 cm). In average, for a sustainable harvest of 40% commercial trees, the maximum extraction percentage of small trees would be around 7.3% annually. Extraction programs should be planned carefully to prevent damage in small classes.

As a general conclusion, simulations based on populations from EPFR showed that resting periods (from one harvesting season to another) of 15 or more years is fundamental for sustainable management of *Guaiacum sanctum*. Nevertheless, this should be analysed and defined on a case-by-case basis, and in relation to the proposed extraction percentage and to the population survey results of the sites that are to be harvested.

Other relevant aspects related to the study

**National workshop:** The National Commission for the Knowledge and Use of Biodiversity (CONABIO), with the support of the CITES Mexican Authorities, organized The National Workshop on Conservation, Management and Sustainable Use of Lignum Vitae (*Guaiacum sanctum*) in Mexico (Mexico City; 11-12 October 2006). The main objective of the workshop was to establish the guidelines and the coordination mechanisms to promote the conservation and sustainable use of *G. sanctum* in Mexico. To accomplish this, the participants focused on: obtaining a first diagnosis of the species at a national level in order to define priority areas for conservation, restoration, and sustainable use. To define general guidelines to serve as a baseline for the development of management plans, and mechanisms for institutional coordination through which there can be a follow up on the national conservation, use and monitoring programs of the wild populations of Lignum Vitae and its habitat. Among other things, difficulties that can be found in the management and use authorizations were discussed with possible solutions to them.

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