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

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Fifteenth meeting of the Plants Committee
Geneva (Switzerland), 17-21 May 2005

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

1. This document has been prepared by the *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), which is the institution entrusted with carrying out the study on "Abundance, distribution and conservation status of *Guaiacum sanctum* L. in Mexico".

2. Pursuant to Decision 11.114 (Rev. CdP12), on *Guaiacum* spp. and earlier discussions during the 11th and 12th meetings of the Plants Committee, Mexico established a project to evaluate the status of the wild populations of *G. sanctum* en Mexico, which led to a study that was started in 2003. Phase I of the study, the population phase, was completed during 2003 and 2004, and a summary of its results is annexed hereto. The Annex also contains a progress report covering the second phase of the study, which involves long-term tracking of some populations in order to study certain population dynamics aspects.

3. The primary objective of the study is to examine the present distribution, abundance and population dynamics of *G. sanctum* (and sympatric populations of *G. coulteri*) in Mexico, in order to determine its conservation status and abundance. Using that information, it is intended to establish the bases for identifying priority areas for the conservation of the species and evaluating certain important aspects of its natural history, with a view to determining the viability of the populations in Mexico and, if necessary, putting forward a plan for management and sustainable use.

4. The study is being carried out by a team of scientists from the CIECO (UNAM, Morelia Campus), led by Dr Miguel Martínez Ramos and comprising the following researchers: Dr Gerardo Bocco and Dr Alfredo Cuarón (GARP and SIG), Dr Guillermo Ibarra and Dr Diego Pérez (plant communities), Dr Ken Oyama (population genetics) and Dr Mauricio Quesada (reproductive biology). The team received technical support from CONABIO, through the Technical Directorate for Analysis and Priorities, which with assistance from Dr Oswaldo Téllez generated and validated the potential distribution maps. CONABIO was also responsible, through the Directorate for Outreach and International Affairs and the Directorate for Project Evaluation, for coordination, review of reports and administration of the project.

5. The total cost of the project is MXN 382,500 (USD 35,350) and it has been implemented with funding from the Governments of Mexico, the United States of America and Germany:

   a) CONABIO (Mexico): MXN 120,085 (USD 10,832).

   b) United States Forest Service: MXN 155,250 (USD 15,000).

c) Government of Germany (through the CITES Secretariat): MXN 107,165 (USD 9,518).

6. Using the information produced by the study, Mexico's Authorities will develop, in a joint approach involving both scientists and producers, a strategy for management, conservation and sustainable use of *Guaiacum*, such that commercial exports can be kept to sustainable levels.

7. The results of this study lead us to conclude that the species 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. These findings confirm that the species is not at risk of extinction and that it is correct to keep it in Appendix II in order to ensure that use of it and international trade in it do not place it at risk.

8. The Annex to the present document shows the results of Phase I of the study and the progress with Phase II.

RESULTS OF PHASE I AND PROGRESS WITH PHASE II OF THE STUDY "ABUNDANCE, DISTRIBUTION AND CONSERVATION STATUS OF *GUAIACUM SANCTUM* L. IN MEXICO"

1. Potential distribution

Guaiacum sanctum L. (Zygophyllaceae), commonly known as 'lignum vitae', is a tree species distributed in the tropical regions (annual precipitation less than 1500 mm), between 5 and 200 m above sea level, of the south-east of Mexico, the south of the Florida Peninsula, the Caribbean and some areas of Central America (Jiménez, 1999, Escalante 2000). Existing herbarium data (MEXU-Biology Institute, UNAM, Missouri Botanical Garden) indicated that *G. sanctum* is found in Mexico only in the States of Yucatan, Quintana Roo, Campeche and in a few locations in the States of Chiapas and Oaxaca. By contrast, its congener *G. coulteri* apparently covers a wide area of the country, being found in the States of Oaxaca, Puebla, Michoacán, Jalisco, Nayarit, Sinaloa and Sonora.

The sampling areas were determined on the basis of potential distribution maps for *Guaiacum sanctum* and *G. coulteri*, which were drawn up using Desktop GARP. The model was created using herbarium specimen records, which had been drawn from the CONABIO database of scientific collections. The distribution maps for potential niches were the outcome of 30 iterations of the algorithm, and were refined using probabilistic maps covering distribution, eco-regions, biogeographical provinces and recent vegetation studies. Analysis indicated that the potential distribution of *G. sanctum* in Mexico is primarily in large areas of the Yucatan Peninsula, in the States of Campeche, Yucatan and Quintana Roo, and also in restricted areas of the States of Chiapas (principally around the "La Angostura" dam), Oaxaca (in areas on the Tehuantepec isthmus and the coast) and Guerreo (some coastal areas). For *G. coulteri*, analysis suggests a distribution throughout the Pacific coastal region, from the State of Oaxaca as far as Sinaloa. The potential distribution maps were presented in the first progress report to the Plants Committee at its 13th meeting (see PC13 Inf. 2).

2. Population censuses

Field trips were undertaken in 2003 and 2004 to carry out population censuses in 23 locations identified as being somewhat likely to contain populations of *Guaiacum sanctum*. Seven of these were located in Campeche, seven in Yucatan, two in Oaxaca, one in Chiapas and six in Quintana Roo. Populations of *G. sanctum* were found in 11 of those locations. In one of the locations in Oaxaca a population of *G. coulteri* was also found, and the interviews and vegetation censuses carried out would indicate that this species is more abundant than *G. sanctum* in that region. Some of the populations recorded gave indications that adult trees had been felled in previous years. Non-exhaustive censuses of the populations of *Guaiacum sanctum* and of the associated arboreal vegetation were taken in those 11 localities.

Following more detailed exploration through the basin of the *La Angostura* dam in Chiapas, including locations indicated in herbarium information, it was confirmed that *G. sanctum* is not currently present in that region. It is important to note that native mature forest is very rare in the region, and the investigation located only small and very disturbed fragments of natural vegetation, or of secondary vegetation. The greater part of the area is covered by crop fields and/or by fields for cattle ranching. This might indicate that *G. sanctum* is very rare or that it is virtually extinct in that region.

Table 1 shows density values for the populations of *Guaiacum sanctum*, for four size-categories in the four States studied. From this information, three important aspects stand out:

a) At most of the sites, particularly in the locations in Campeche, total density is high for the populations of *G. sanctum*, including trees with diameter at breast height (DBH, 1.3 m above the ground) greater than 10 cm;

b) Almost all the populations have an abundant quantity of seedlings and small trees, suggesting that these populations have good regeneration potential; and

c) The results indicate that the abundance of the species varies significantly from region to region and that even within one area the density of *G. sanctum* varies to a large degree.

Table 1. Average population densities of *Guaiacum sanctum* in different States in the Yucatan Peninsula and the Tehuantepec isthmus, Mexico.

Average density in specimens/ha (per cent)				
State	**Seedlings**	**Saplings**	**Trees 1**	**Trees 2**
Campeche	17866 (87%)	1740 (8%)	722 (4%)	244 (1%)
Quintana Roo	1080 (61%)	365 (21%)	270 (15%)	50 (3%)
Yucatan	192 (48%)	54 (14%)	92 (23%)	62 (16%)
Oaxaca	235 (78%)	5 (2%)	45 (15%)	15 (5%)
Countrywide	4843 (84%)	541 (9%)	282 (5%)	93 (2%)
Variation	**48-87%**	**2-21%**	**4-23%**	**1-16%**
Maximum (State)	17,866	1,740	722	244
Minimum (State)	192	5	45	15
Maximum (county)	55,575	3,440	1,430	300
Minimum (county)	10	0	10	10

Note: The density values are expressed in specimens per hectare, divided among seedlings (< 50 cm tall), saplings (small trees between 51 and 150 cm tall), trees-1 (trees 1 to 10 cm in diameter at breast height, DBH) and trees-2 (> 10.1 cm DBH).

In general, in all the locations the proportion of specimens of G*uaiacum sanctum* diminishes logarithmically as trees of a greater DBH are taken into account, and a significant proportion of seedlings and young trees (saplings) is observed. This pattern indicates that the populations observed have good regeneration potential, in other words the existing seedlings and saplings could in the future replace the large-sized trees as they die off.

Within the general pattern described above, important differences may be noted among the populations studied. The populations in Campeche have trees in all size categories. These are high-density populations with very good regeneration potential. On the other hand, two sites in Oaxaca have some trees of a small size and some seedlings that appear to be marginal populations within the range of *G. sanctum* in Mexico. Thirdly, the population in Yucatan shows good regeneration potential and is distinguished by having trees that do not exceed 15 cm DBH. Finally, some populations have no trees at all in some intermediate categories of DBH, one possible explanation for which that these gaps in the size pattern reflect periods when there was no natural recruitment, or else severe cases of tree mortality. One of the latter might possibly be due to selective felling, a situation that is notable in the medium semi-evergreen forest locations in Quintana Roo and Campeche.

3. Allometric comparison between the two species

Given that the development of trees entails limits on upward growth and on the thickness of the trunk, which are regulated by principles of allometry, by physical constraints and by environmental factors, the study undertook to model the allometric relationship between the height and the DBH of G*uaiacum sanctum*. The results indicate that DBH increases relatively more than height as the trees develop. Notwithstanding the wide variation in the size of the *G. sanctum* trees from one population to another, all of them demonstrate the same pattern of allometric growth. The sole population of *Guaiacum coulteri* found in the censuses shows an allometric relationship different from that observed in *G. sanctum*. In this case, the relative upward growth is greater than the growth in DBH, which means that specimens of *G. coulteri* are less tall than *G. sanctum* and the stem is noticeably thicker. Specimens of *G. sanctum* are relatively tall, with a columnar trunk, and have an open crown and well-separated branches. By contrast, *G. coulteri* is short, with a short trunk, a full crown and a tendency to ramify near the base of the trunk.

Additionally, it has been observed that the maximum height and the basal area (m^2/ha) of G*uaiacum sanctum* increase along with average annual precipitation. It appears that the limit on the growth of this species in the region studied occurs at sites with a precipitation of 500 mm, where the trees do not exceed 10 m in height. In the sites with precipitation above 1,000 mm there is a significant variation in the average maximum height of the trees and the basal area of the species, this variation resulting from factors other than the precipitation.

4. Types of vegetation and habitat

The types of vegetation in which populations of *Guaiacum sanctum* were found were medium semi-deciduous forest and low deciduous forest (as classified by Hernández and Miranda, 1967) or tropical evergreen forest (locations in the States of Campeche and Quintana Roo) and tropical deciduous forest (locations in Motul-Telchac, Yucatan, Nizanda and Huatulco, Oaxaca), respectively, as in the classification by Rzedowski (1978).

In the locations studied, *Guaiacum sanctum* was found on flat or moderately sloping (< 14°) ground, with a soil depth varying between 7 and 24 cm. In the low deciduous forests the average height of the canopy is between 5 and 10 m and in the medium semi-evergreen forests it is between 13 and 18 m. In November, after the main rainy season, the canopy of these medium forests demonstrated between 8 and 12 per cent of canopy opening 1 m above the ground. In this same period, the low forest of Yucatan demonstrated 54 per cent of opening. In the dry season, in April, the medium forests of Quintana Roo and Los Campeche demonstrated between 12 and 54 per cent of canopy opening while in the low deciduous forests of Oaxaca the figure was between 77 and 85 per cent. In all the locations in the State of Campeche, in the medium semi-evergreen forest, *G. sanctum was* the dominant or co-dominant species, accounting for between 4 and 30 per cent of all the trees recorded for a site and between 5 and 43 per cent of the basal area of the community of trees having DBH > 5 cm. These forests tend to occur on karst hillsides and flat areas not subject to flooding. In the locations in the States of Yucatan and Quintana Roo *G. sanctum* was not the dominant species although it was among the 10 most significant species in terms of basal area. In these locations, *G. sanctum* represented between 4 and 11 per cent of the total basal area of the arboreal communities. In the State of Oaxaca, this species is not structurally important since it represented less than 3 per cent of the total basal area of the arboreal communities. These results indicate that *G. sanctum* has its most significant presence in the State of Campeche and its least significant in the low deciduous forest of the Tehuantepec isthmus and the Oaxaca coast.

5. Current relative density and distribution

On the basis of the interviews carried out, the field explorations, the herbarium collections, the map of the vegetation of Calakmul, Campeche, Mexico (Martínez & Galindo 2002) and the non-exhaustive censuses undertaken, a preliminary map was drawn up of the distribution and abundance of G*uaiacum sanctum* in the south-east of Mexico. In this map, five areas can be distinguished: 1) the coast of Oaxaca and the Tehuantepec isthmus, 2) the centre of the State of Campeche (particularly the area of "Los Chenes" and the northern central part of the Calakmul reserve), 3) the coastal region of the northern central part of Yucatan, 4) the region of Cancún and Puerto Morelos, and 5) the Sian Ka'an reserve and its surroundings (see Figure 2). Based on herbarium references, it was anticipated that *G. sanctum* would be encountered in the central low-lying area of Chiapas, but the field explorations and the interviews carried out in this area show that the species is locally extinct in the region. This may be due, as remarked above, to the intense deforestation and conversion of the forests into agricultural fields.

Figure 2 below shows the distribution and abundance of G*uaiacum sanctum* in the south-east of Mexico, drawn up on the basis of herbarium collections, interviews, field explorations, non-exhaustive censuses and bibliographical research (see details in the text). The zones marked off by red broken lines indicate areas that formerly had or currently have populations of *G. sanctum*. High population density: more than 300 trees with DBH > 10 cm per hectare, medium density: between 50 and 100 trees per hectare, low density: fewer than 20 trees per hectare.

Out of the five areas of distribution shown on the map (Figure 2) the most important, given its size and the density of the *Guaiacum* populations, is the one shown in the centre of Campeche. The area of the Oaxaca coast and the Tehuantepec isthmus represent areas with a low density of *G. sanctum*, as does the extreme north-eastern area of the Peninsula, while the northern central coastal region of Yucatan and the environs of the Sian Ka'an reserve present an intermediate density.

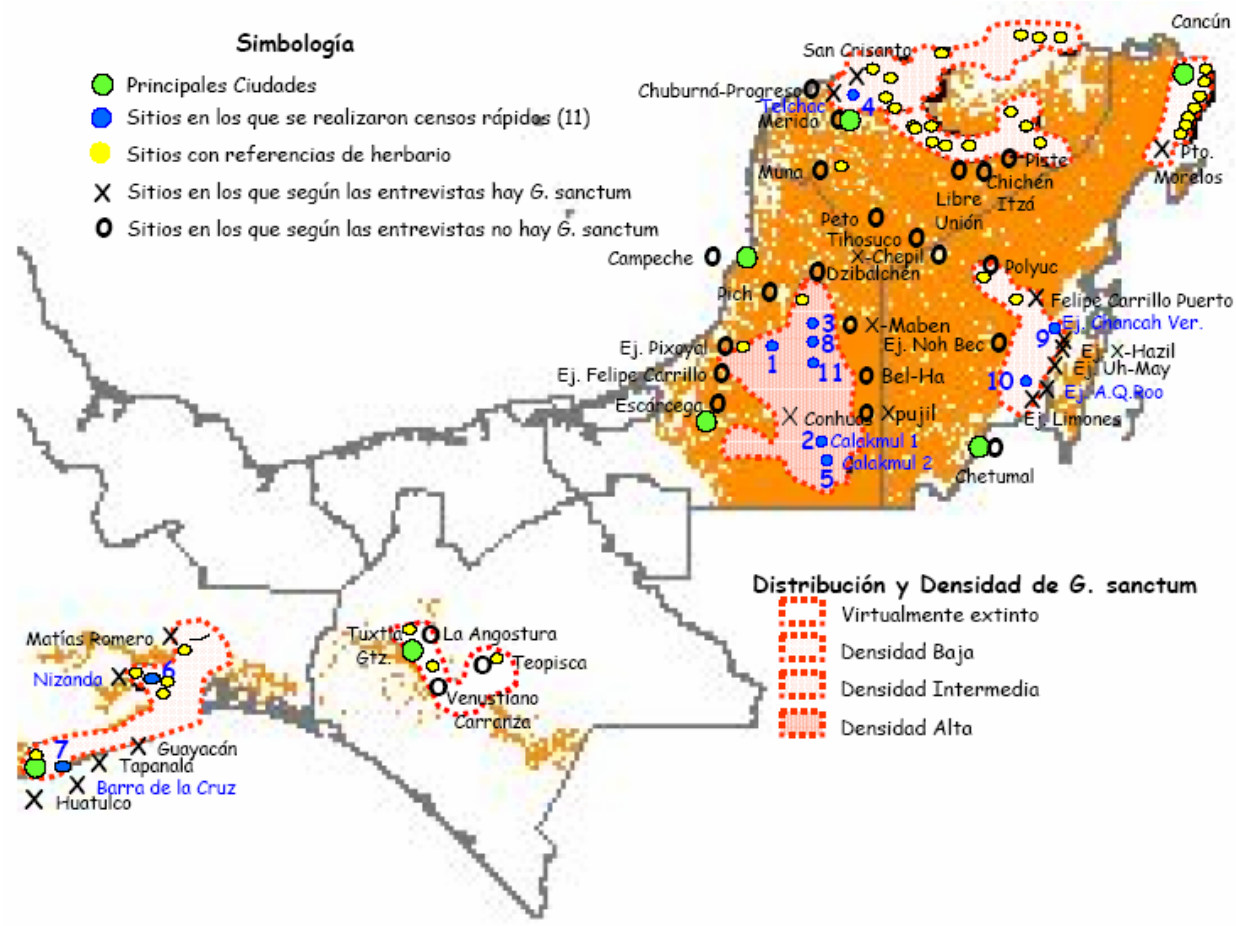

Figure 2. Distribution and abundance of G*uaiacum sanctum* in the south-east of Mexico.

6. Conclusions

The results confirm the presence of G*uaiacum sanctum* in the tropical regions of the south-east of Mexico, in the Yucatan Peninsula (in the States of Yucatan, Quintana Roo and Campeche) and in locations on the Tehuantepec isthmus and the coast of the State of Oaxaca. Given this information, we can state that *G. sanctum* is distributed, in those areas, in locations with an average annual precipitation of between 500 and 1,500 mm and at a height of between 3 and 170 m above sea level. *G. sanctum* reaches a maximum height of 20 m and the maximum diameter of the trunk at breast height (1.3 m above ground level) is 60 cm. It occurs in karstic ground, either hillsides or flat, not subject to flooding. We can confirm that under natural conditions, or with low-intensity management, the populations of *G. sanctum* tend to have an abundant supply of seedlings and young trees, suggesting that the requirements for germination and development in the early growth stages are not very strict (e.g. Stoffers 1984). Practically all of the populations studied provided evidence of high regeneration potential.

The results achieved indicate that the main range of *Guaiacum sanctum* is in the Yucatan Peninsula. This distribution is not homogeneous and is concentrated in three main areas. The most important, in terms of size and abundance, is the central area of the State of Campeche, where *G. sanctum* may reach population densities of 375 trees with DBH > 10 cm per hectare and it is a dominant species in the plant community. Areas of lesser density are found in the Sian Ka'an biosphere reserve and its surroundings and in the northern part of the State of Yucatan. Marginal populations are found in the coastal area and on the Tehuantepec isthmus in the State of Oaxaca. In those regions, the *Guaiacum* trees vary significantly in size and foliage characteristics, with the shortest, having leaves of the smallest area, occurring in the low deciduous forests and the tallest, having leaves of the greatest area, in the medium semi-evergreen forests.

In the case of *G. coulteri*, it was determined that for the same DBH and within the low deciduous forest of Huatulco, Oaxaca, this species is not so tall, and has a wider and less deep crown than *G. sanctum*.

Evidence was found in various locations indicating that *Guaiacum sanctum* is protected by the communities and administrative penalties imposed by the authorities in charge of communal farming protect the species from misuse or unnecessary cutting. In the *Guaiacum* forests, fire is not used but in some locations goats are kept as livestock. Observations in the field indicate that the most important risk to the continued survival of the *Guaiacum* tree populations is the change in land use, from forest to farming systems, as has already occurred in the Angostura region in Chiapas. The impact of the current tree-felling practices will be evaluated by means of the more detailed studies of population dynamics that are under way.

7. Other activities and ongoing analysis

As a complement to the population censuses, the botanical specimens collected in the course of the plant censuses are being processed and taxonomically identified. In addition, a physical and chemical analysis of the soil samples obtained from those sites is being performed, and the tissue samples collected will be used to determine the populations' degree of genetic viability, including local and regional levels of genetic variability, levels of endogamy and gene flow, problems of gene drift and the spatial dimension of the genetic variation. Based on that knowledge an evaluation will be made of the possible risks of extinction presented by the remainder populations of *Guaiacum* owing to genetic bottlenecks.

For the purposes of the section of the study covering the population dynamics of *Guaiacum sanctum* two permanent observation plots have been established, with a view to determining principles of sustainable use of populations of the species. In the plots a statistically representative group of specimens has been marked, representative of the different stages of growth. One of the plots is located in the Calakmul biosphere reserve and the other in the forest extension of the Pich communal farm, these being sites where abundant populations of G*uaiacum sanctum* occur and representing conditions of forestry conservation and forestry use, respectively, thus making them suitable for the objectives of the study. In these plots a population census has been carried out, and the local shading and the topography of the ground have been described, making it possible to determine the density and structure of the populations and the allometric relationships of the trees in the populations under study. Additionally, a life table was generated and a simple preliminary matrix model was developed, into which the information gathered on growth, mortality and reproduction in the permanent plots will subsequently be inserted.

The preliminary results of the tracking on the permanent plots indicate that at both sites there are populations whose pattern is dominated by young trees. The low-management population is currently high-density, with 11 trees to the hectare in sizes that could be used for commercial purposes (DBH > 35 cm). Based on the current structure of the population, and assuming that the DBH is an indicator of the age of the trees, it is assumed that the populations studied undergo a severe process of mortality during the seedling and juvenile tree stages and a low death rate in the adult stages. If the trees grow at a rate of 0.5 to 1 mm of DBH per year, it would be anticipated that the largest trees encountered (80 cm DBH) would be at least between 800 and 1,600 years old.

Based on the preliminary matrix model, simulating annual rates of mortality and of tree-felling estimated in accordance with the observations made in 2004, it is suggested that a felling rate of 50 per cent of the usable trees once every 10 years will be able to maintain the population in balance, if steps are taken to ensure the ongoing recruitment of at least five young trees reaching a minimum DBH of 1 cm every year. The model suggests that sustainable use of G*uaiacum sanctum* should be based on promoting the recruitment of young trees and very limited felling of trees at long intervals of time. These tentative suggestions will be verified when models are built of the population dynamics based on the dynamic information (survival, growth and reproduction) that is being gathered in the permanent plots that have been established.