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Conservation Status of Cryosophila with Special Reference to the Critically Endangered Cryosophila cookii and Cryosophila williamsii

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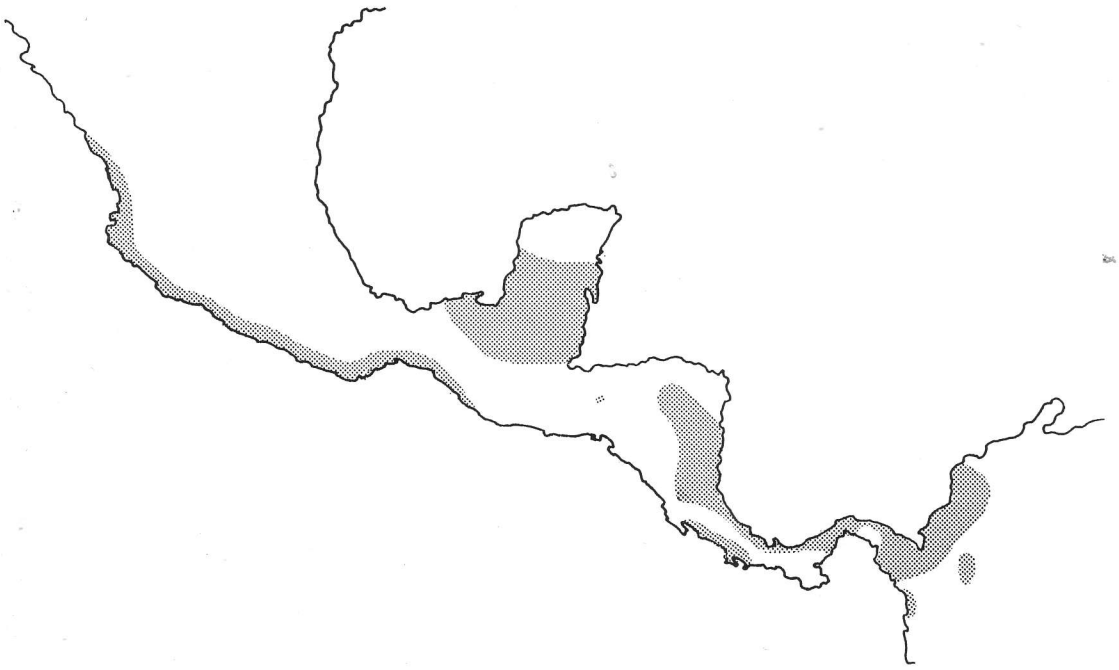
As is now widely known, the world's remaining tropical forests are rapidly disappearing. This has serious consequences for the long-term survival of many palms since an estimated 75% of the roughly 2 700 palm species are rain forest species (Dransfield 1978) and fully 80% of palm species are found only in the wild, having never been cultivated (Johnson 1988). Furthermore, since geographically restricted species are those most immediately and generally most gravely affected by local tropical deforestation and more than 90% of palm species have such restricted distributions (Good 1974), the palm family is probably the most threatened among all major plant taxa (Myers 1984).

The International Union for the Conservation of Nature and Natural Resources (IUCN) Threatened Plants Unit has provisionally identified about 100 seriously threatened palm species worldwide (Dransfield et al. 1988, Johnson 1988). Although this might not seem exceptionally high for such a large, mainly tropical, family, many more palms are undoubtedly endangered since the conservation status of the majority of palm species is unknown. In the New World, for example, data for about 60% of the over 1 100 palm species were insufficient to allow the Palm Specialist Group of the IUCN Species Survival Commission to determine whether they were threatened or not (Johnson 1986, 1987; Dransfield et al. 1988). Such ignorance reflects how poorly known botanically many tropical areas still are, but it is also a result of palms having been historically ignored by most general plant collectors because they are so difficult and time-consuming to collect (frequently being large and inaccessible). Consequently, for most palms, reliable demographic and distributional data do not exist. Until recently this has been the case for most species of the largely Mesoamerican palm genus *Cryosophila*. However, extensive field studies carried on throughout the range of the genus (Fig. 1) as part of a critical taxonomic revision (Evans 1995) have provided the information necessary to evaluate the conservation status of all but one species of *Cryosophila*.

Following a brief synopsis of the genus, I will summarize the important diagnostic features, geographic distribution (for detailed distribution maps see Evans 1995), and conservation status for each of the 11 taxa of *Cryosophila* (ten species and two subspecies). Lastly, I will consider in more detail the status of the two most critically endangered species of *Cryosophila*—in fact, probably two of the most threatened neotropical palm species—*Cryosophila cookii* and *Cryosophila williamsii*.

General Information on the Genus Cryosophila

Unique to *Cryosophila*, and its most distinctive generic characteristic, are the usually descending, often numerous, long, branched spines derived from roots that grow out from and are distributed variously along the usually solitary trunk, sometimes forming a basal cone. These root-spines make *Cryosophila* one of the most easily recognized genera of palms. *Cryosophila* flowers are also distinctive and essentially of similar form across the genus. They possess three basally connate sepals, three distinct petals, an androecium with six flat thin filaments connate for some length in a narrow tube, and three separate carpels with long thin styles exserted at anthesis. Several distinctive leaf characteristics are shared by *Cryosophila* and only two or three of its seven most closely related genera (i.e., the neotropical apo-



1. Distribution of *Cryosophila*.

carpous Corypheae clade; Uhl et al. 1995). These are: (1) leaf blades that are split near the midline along an abaxial fold, usually nearly to the base, effectively dividing the leaf into two halves—shared by *Cryosophila*, *Chelyocarpus*, *Itaya*, and some species of *Trithrinax*; (2) leaf segment midribs with vascular bundles embedded within a central colorless ground parenchyma and completely enclosed within a fibrous cylinder occupying most of the rib—apparently shared only by *Cryosophila*, *Itaya*, and *Schippia* among all 40 genera of coryphoid palms; and (3) petiole bases that are split basally and through which the developing inflorescence buds emerge—shared by *Cryosophila* (all species except *C. nana*), *Itaya*, and *Thrinax*.

Although *Cryosophila* is relatively widely distributed geographically (see Fig. 1), all ten species of the genus have rather limited distributions (eight of the ten species are confined to only one or two countries) and several are extremely local endemics. Costa Rica, with four, has the most species of *Cryosophila*—*C. cookii*, *C. grayumii*, *C. guagara*, and *C. warscewiczii*. *Cryosophila* is the only coryphoid genus with its distribution centered in Central America, with extensions east into South America and north into Mexico. Only three instances of sympatry occur in the genus, and each of these involves one species occupying a specialized habitat within the range of another more generalist species (the local endemics *C. cookii* and *C. bartlettii* within the range of the widely distributed *C. warscewiczii*, and *C. grayumii* within the range of the similarly distributed *C. guagara*). *Cryosophila grayumii* and *C. guagara* are occasionally syntopic, and the rare *C. cookii* is usually found with *C. warscewiczii* (Fig. 2). For the most part, the species of *Cryosophila* are distributed as a more or less linear series of disjuncts across the Central American corridor.

All species of *Cryosophila* are forest understory trees (to about 15 m tall). With the exception of the dry-forest *C. nana*, all species of *Cryosophila* are found in lowland (rarely over 1 200 m) humid to wet forests. *Cryosophila kalbreyeri* and *C. stauracantha* occur in both moist and dry forests. Five of the ten *Cryosophila* taxa are calciphiles (*C. bartlettii*, *C. grayumii*, *C. kalbreyeri*, *C. stauracantha*, and *C. williamsii*), with *C. bartlettii* and *C. williamsii* being restricted to rocky limestone outcrops (Figs. 3, 4). With the exception of *C. nana*, the remaining *Cryosophila* taxa are apparently calcifuges.

Although all species of *Cryosophila* were

apparently used extensively at one time, such use is fairly limited today. The name *escoba* ("broom") or *palma de escoba* is used variously for most species throughout the range of the genus and refers to the once common practice of using the very durable leaves to make brooms (Figs. 5, 6). In addition, all the larger leaved species were frequently used for making thatch before the widespread availability of cheap, corrugated metal roofing, and they still serve this purpose in some rural areas. The bitter tasting "palm hearts" of most species are still eaten occasionally to commonly for various intestinal ailments. In fact, this use has decimated populations of *Cryosophila* in some areas. Lastly, various species of *Cryosophila* are sometimes cultivated as ornamentals, the root-spines being easily removed if desired.

Seven of the ten species of *Cryosophila* are currently endangered or threatened (*C. bartlettii*, *C. cookii*, *C. grayumii*, *C. guagara*, *C. nana*, *C. kalbreyeri*, and *C. williamsii*), with *C. cookii* and *C. williamsii* unlikely to survive, except for perhaps a few isolated individuals, much past the end of this decade. *Cryosophila macrocarpa* appears to be extremely rare, but its distribution and demography are too poorly known for an assessment of its conservation status. The populations of the remaining two species (*C. stauracantha* and *C. warscewiczii*) are rapidly declining, but since these are the most widely distributed species they are for the moment relatively secure, at least in portions of their ranges. Unless the destruction of tropical forests halts immediately throughout the range of the genus, which is, unfortunately, an unlikely occurrence, I see little chance of long-term survival for most species of *Cryosophila*.

The Species

Cryosophila bartlettii R. Evans (Fig. 7)

This species is most similar to *C. kalbreyeri*, but can be distinguished by its typically longer, more spiny stems, smaller leaves, inflorescences with longer prophylls, and flowers with longer stamen tubes. It is characterized by small fruits and seeds. Only *C. stauracantha* typically has fruits as small, but the inflorescences of *C. stauracantha* are usually larger with fewer peduncular bracts and more and larger first-order branches. *C. bartlettii* is known only from limestone outcrops in the Lago Alajuela (formerly known as Madden Lake) watershed in central Panama at an elevation of about 100 m.

Little undisturbed forest remains in the Lago Alajuela watershed area, and this species is extremely rare. Presumably much of the original habitat of this species was inundated by the rising waters of Lago Alajuela, formed by the damming of the Río Chagres during construction of the Panama Canal. It is reportedly present on some of the small forested islands in Lago Alajuela near the mouth of the Río La Puente, which enters the lake from the southeast. Although more field work is needed to delimit better its exact distribution, this species is unquestionably endangered.

Cryosophila cookii Bartlett (Figs. 8–10)

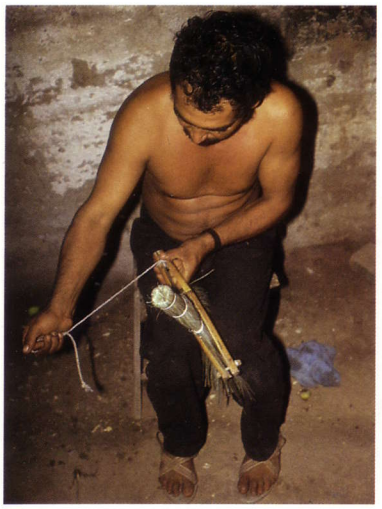
The inflorescence of this palm, with its characteristic densely fastigiate rachillae spiraling around the main axis, makes it the most distinctive species of *Cryosophila*. Its large size and extremely spiny trunk are also diagnostic. The type specimen (*Cook & Doyle 635*, Río Hondo, Costa Rica) appears to have uncharacteristically small leaves and a similarly small infructescence. This species is confined to a small area of Caribbean lowland wet forest in eastern Costa Rica, just south of Tortuguero National Park. Within this area it is restricted to low-lying lands, near sea level, having very wet soil most of the year, yet never seasonally inundated for lengthy periods.

Nearly all of the original forest in which this species presumably once occurred has been converted to cattle pastures or banana plantations. Extrapolating from estimates of present population density and the amount of original forest remaining in the presumed historical range of this species, I suspect the total adult population size to be only about 100, with perhaps only a small fraction of this occurring within Tortuguero National Park, which for the most part lacks suitable habitats.

Cryosophila grayumii R. Evans (Figs. 11,12)

This *Cryosophila* is characterized by possessing the fewest peduncular bracts (2–3) in the genus. The leaf blade is also diagnostic, being less divided than in other species of *Cryosophila*. Its inflorescences have the shortest first-order branches and rachillae in the genus, and its inflorescences and leaves are typically smaller than those of any other species except *C. nana*. *Cryosophila gra-*

2. Syntopic *Cryosophila warscewiczii* (left) and *C. cookii* (right). About ½ km northwest of San Geraldo, Costa Rica. 3. Stem base of *Cryosophila bartlettii* showing adventitious roots and root-spines. Plant from which *Evans 157* was collected. Natural limestone bridge over Río La Puente, Panama, type locality for this species. Note limestone outcrop, habitat to which this species is restricted. 4. Stem base of *Cryosophila williamsii* showing adventitious roots and root-spines. Plant from which *Evans 157* was collected. Punta Gorda, Lago Yojoa, Honduras, type locality for this species. Note limestone outcrop, habitat to which this species is restricted. 5. Wild-collected leaves of *Cryosophila nana* spread out to dry in preparation for making brooms. Zapotillo, Jalisco, Mexico.



6. Local craftsman making a broom-head from the dried leaves of *Cryosophila nana*. Zapotillo, Jalisco, Mexico. 7. Inflorescences of *Cryosophila bartlettii*. Plant from which *Evans & Grayum 183* was collected. Natural limestone bridge over Río La Puente, Panama. 8. *Cryosophila cookii*. Uncollected plant about 3 km north of San Gerardo de Colorado, Costa Rica. Note height (stem about 14 m tall) of this, typically the largest, species of *Cryosophila*. 9. Stem base of *Cryosophila cookii* showing the dense, tangled mass of extremely long root-spines, diagnostic for this species. The single individual (uncollected) encountered during a 1-wk search in Tortuguero National Park. Vicinity of the abandoned Río Sierpe guard station on the Río Sierpe north of La Aurora, Costa Rica.

10. Inflorescences and infructescences of *Cryosophila cookii* showing the fastigiate rachillae spiralling along the inflorescence rachis, diagnostic for this species. Plant from which *Evans 133* was collected. About 1 km northwest of San Gerardo de Colorado, Costa Rica. 11. *Cryosophila grayumii* showing typical arching stem habit and leaves with relatively few divisions, diagnostic for this species. Uncollected plant about 8 km north of Ciudad Neily, Costa Rica, the type locality for this species. 12. Small infructescences of *Cryosophila grayumii*. Plant from which *Evans 173* was collected. Same locality as in Figure 11. 13. Large, deflected inflorescences of *Cryosophila guagara*. Plant from which *Evans 147* was collected. About 5 km southeast of Paso Canoas, Panama. Note large, persistent rachis bracts, diagnostic for this species.

yumii is known only from the Pacific slope of Costa Rica at elevations of 100–650 m. It is found in small, scattered populations on slopes along the Fila Costeña in the south and a single more northerly disjunct population in the Cordillera de Tilarán.

This species can be found syntopically with *C. guagara* on Fila Retinto, just north of the town of Palmar Norte in southern Costa Rica. Whereas *C. guagara* was common throughout the Golfo Dulce area to about 500 m or more, this palm is restricted to limestone slopes. Within this specialized habitat, it is relatively common. This habitat is very limited in Costa Rica, and its forests are rapidly disappearing. There may be a few more remote undiscovered populations, but even so, the species must be considered endangered. A search for it in Panama near the Costa Rican border east of the Fila de Cal population failed to locate any individuals. Future searches in Panama are also very likely to be unsuccessful since almost no forest remains in this part of the country, having already been converted to agriculture.

Cryosophila guagara P. H. Allen (Fig. 13)

This species is characterized by its long, deflected inflorescences with especially persistent rachis bracts, many of which remain on the inflorescence into fruit. Its long styles are also diagnostic. It is found at elevations from sea level to more than 500 m in the lowland moist to wet forests of the Golfo Dulce area of southern Costa Rica and adjacent Panama, and north along the Costa Rican Pacific coast to near the Río Grande de Tárcoles.

In its natural habitat, this palm is often common. Unfortunately, most of this habitat outside the Osa Peninsula (particularly Corcovado National Park) has disappeared. Except on the Osa Peninsula, it can easily be found only in the most remote areas, near the upper elevational limit of the species. Corcovado National Park harbors a large population.

Cryosophila kalbreyeri (Dammer ex Burret) Dahlgren

This species is extremely variable morphologically in most of the characters that are useful elsewhere in the genus for circumscribing species. Consequently, it has few diagnostic features, being identifiable primarily by what it lacks (a less than ideal situation). It is intermediate between *C. bartlettii* and *C. stauracantha*. Although sharing more character states with *C. bartlettii* than *C. stauracantha*, more often *C. kalbreyeri* exhibits a state intermediate between those of these other two species. It differs from *C. bartlettii* by its typically shorter, less spiny stems, larger leaves, inflorescences with shorter prophylls, and flowers with shorter stamen-tubes. It differs from *C. stauracantha* by its more persistent rachis bracts, usually more numerous peduncular bracts, and shorter rachises with shorter first-order branches. This palm is found in a variety of moist to dry forest habitats in eastern Panama and northwestern Colombia at elevations from sea level to 1 200 m.

Cryosophila kalbreyeri comprises two subspecies, reflecting a geographic disjunction. *Cryosophila kalbreyeri* subsp. *kalbreyeri* is a more widespread northern taxon, occurring in northwestern Colombia and extreme southeastern Panama, while *C. kalbreyeri* subsp. *cogolloi* is endemic to Antioquia, Colombia. Subspecies *kalbreyeri* is distinguished from subsp. *cogolloi* by having inflorescences with the rachillae typically proportionately shorter relative to the first-order branches and typically smaller flowers. Although the two subspecies overlap broadly in flowering times, subsp. *kalbreyeri* tends to flower earlier (usually beginning in July) than subsp. *cogolloi*.

Cryosophila kalbreyeri subsp. **kalbreyeri** (Fig. 14)

This subspecies is restricted to northwestern Colombia and adjacent Darién Province in southwest Panama at elevations from sea level to 1 200 m. Nearly all of the original dry forests of northwest Colombia (northern Antioquia, Córdoba, Sucre, and northern Bolívar Departments) have been converted to pasture lands. Consequently, within this area, this palm is very rare, persisting only as scattered individuals or small isolated populations. However, in the western portion of its range (Darién Province, Panama) much forest remains intact and it is still common. The same presumably holds true in the large intact tracts of forest in northern Chocó Department, Colombia, but the demographics and therefore conservation status of the subspecies in this region are unknown.

Cryosophila kalbreyeri subsp. **cogolloi** R. Evans (Fig. 15)

This subspecies is known only from Antioquia Department, Colombia. It has been collected at elevations of 300–1 200 m in the valleys of the Río Porce in central Antioquia and the Río Claro-

Corconá Sur in extreme southeast Antioquia. Little remains of the natural vegetation of the inter-Andean valleys of Antioquia Department. This palm is known from only a few small (with one exception) populations, and must therefore be considered endangered. The one known relatively large and stable population occurs in a small area of primary forest along the steep slopes of the Río Claro canyon. This forest occurs within a privately owned ecological refuge in San Luis "Municipio" (≈Township), about 30 km west of the Río Magdalena, just south of the highway from Medellín southeast to Puerto Triunfo on the Río Magdalena. The future of this small island of intact forest, and therefore that of the only known substantial population of this subspecies, is uncertain.

Cryosophila macrocarpa R. Evans (Fig. 16)

This palm is easily recognizable by its very large fruits and very large, deeply sulcate seeds. The inflorescences, with a long prophyll and relatively few, long peduncular bracts, are also diagnostic, as are the large leaves. It is known only from the type locality, an area of slightly disturbed lowland wet forest, near sea level, on the floodplain of the Río Valle near the northern limit of the Golfo de Tribuga, Colombia.

Extensive primary forest remains in the immediate area of the type locality as well as most of the entire Golfo de Tribuga coastal region, due to its remoteness. The area is very poorly known botanically, and therefore this species may occur throughout the region. However, it is very rare and localized within its known bottomland habitat, apparently occurring only in scattered small populations. It does not occur on the nearby slopes where *Chelyocarpus dianeurus* (Burret) H. E. Moore is very common. One local resident, knowledgeable enough to distinguish these two superficially similar palmate-leaved species, reported *C. macrocarpa* to be more common on Cabo Corrientes than in the El Valle area. Cabo Corrientes delimits the southern end of the Golfo de Tribuga about 70 km to the south.

18. Stem of *Cryosophila nana* showing the dense, tangled mass of short root-spines, typical for this species. Uncollected plant in the same population as the individuals in Figure 17.

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14. *Cryosophila kalbreyeri* subsp. *kalbreyeri*. Plant from which *Evans & Cogollo 228* was collected, with Alvaro A. Cogollo of the Jardín Botánico "Joaquín Antonio Uribe" in Medellín, Colombia. About 40 km northwest of Montería, Córdoba, Colombia. Compare the deep splitting of the leaf blades, typical for this species, to the shallower splits in the leaf of *C. warscewiczii* in Figure 21. 15. Old infructescences (all fruits having fallen) of *C. kalbreyeri* subsp. *cogolloi*. Plant from which the type of this subspecies (*Evans & Cogollo 247*) was collected. About 4 km northeast of the bridge over the Río Claro on the Medellín–Puerto Triunfo highway, Antioquia, Colombia. Compare the long, pendulous rachillae, typical for this species, to the shorter, often erect rachillae of *C. warscewiczii* in Figure 21. 16. Infructescence of *Cryosophila macrocarpa*. Plant from which the type of this species (*Evans & Ramírez 213*) was collected. About 2 km north of El Valle, Chocó, Colombia. Compare these larger fruits, diagnostic for this species, to the smaller fruits, more typical for the genus, of *C. grayumii* in Figure 12. Also, note the splits at the base of the leaf petioles, characteristic for mature individuals of all species of *Cryosophila*, except *C. nana*. 17. *Cryosophila nana* showing leaves with deep divisions along almost every blade segment, diagnostic for this species. Uncollected plants in the same population from which the neotype of this species (*Evans 239*) was collected. About 18 km N of El Tuito, Jalisco, Mexico.

19. *Cryosophila stauracantha*. Uncollected plant near Teapa, Tabasco, Mexico, the probable type locality for this species. All but four leaves have been removed by locals, presumably for making brooms. Compare the deep splitting of the leaf blades, typical for this species, to the shallower splits in the leaf of *C. warscewiczii* in Figure 21. 20. Young inflorescence and very young infructescence of *Cryosophila stauracantha* showing persistent apical-most rachis bracts on inflorescence, diagnostic for this species. Plant from which *Evans 193* was collected. About 4 km west of Teapa, Tabasco, Mexico. 21. Inflorescences of *Cryosophila warscewiczii*. Plant from which *Evans 140* was collected. About 9 km SW of Bribri, Costa Rica. Compare the shallow splitting of the leaf blade (except the central split), typical for this species, to the deeper splits in the leaves of *C. kalbreyeri* in Figure 14 and *C. stauracantha* in Figure 19. 22. Ascending, compact inflorescence and young infructescence of *Cryosophila williamsii*, diagnostic for this species. Plant from which *Evans 194* was collected. Punta Gorda, Lago Yojoa, Honduras.

Cryosophila nana (Kunth) Blume ex Salomon (Figs. 17,18)

This *Cryosophila* has more unique character states than any other species in the genus. Its unsplit petiole bases, only one order of blade dissection, and sparse abaxial laminar pubescence, as well as the short, dense, spreading root-spines, differentiate it from all other species of *Cryosophila* and make it the only easily and unambiguously identifiable species in sterile condition. It is found at elevations from sea level to 1 700 m (the only *Cryosophila* reported from over 1 200 m elevation) in the dry, deciduous forests (often pine-oak forests) of Pacific coastal Mexico from southern Sinaloa to southern Chiapas near the Guatemalan border.

Much of the original, particularly lower elevation, dry forests along the Mexican Pacific coast have been removed or greatly altered. Consequently, this palm is rare or has disappeared completely from many areas of its former range. However, in other, even disturbed, areas it is still quite common—in Jalisco State, for example. Overall, due to its relatively large geographic distribution, this species appears likely to survive into the foreseeable future, even though many of its populations throughout the range of the species are threatened by continuing dry-forest conversion.

Cryosophila stauracantha (Heynh.) R. Evans (including *Cryosophila argentea* Bartlett and *Cryosophila bifurcata* Lundell) (Figs. 19,20)

The inflorescences of this species are most similar to those of *C. warscewiczii* in having long, narrow, first-order branches, long rachillae (although both are usually shorter in *C. stauracantha* than in *C. warscewiczii*), and caducous rachis bracts. This palm has one inflorescence feature unique within the genus: the apical rachis bracts are briefly joined at their apices and persist longer than all but the most basal bracts. These apical bracts typically fall as a single unit. *Cryosophila stauracantha* also differs from *C. warscewiczii* in having usually smaller inflorescences, smaller fruits and seeds, more deeply divided leaf blades, and a more densely armed trunk, with the basal adventitious roots not morphologically distinct from (only longer than) the root-spines above. This species is found in moist to dry lowland forests of extreme southeastern Mexico, Belize, and northern Guatemala at elevations from sea level to 600 m.

This palm has been extirpated in many areas, but is still locally common throughout much of its historic range.

Cryosophila warscewiczii (H. Wendl.) Bartlett (including *Cryosophila albida* Bartlett) (Fig. 21)

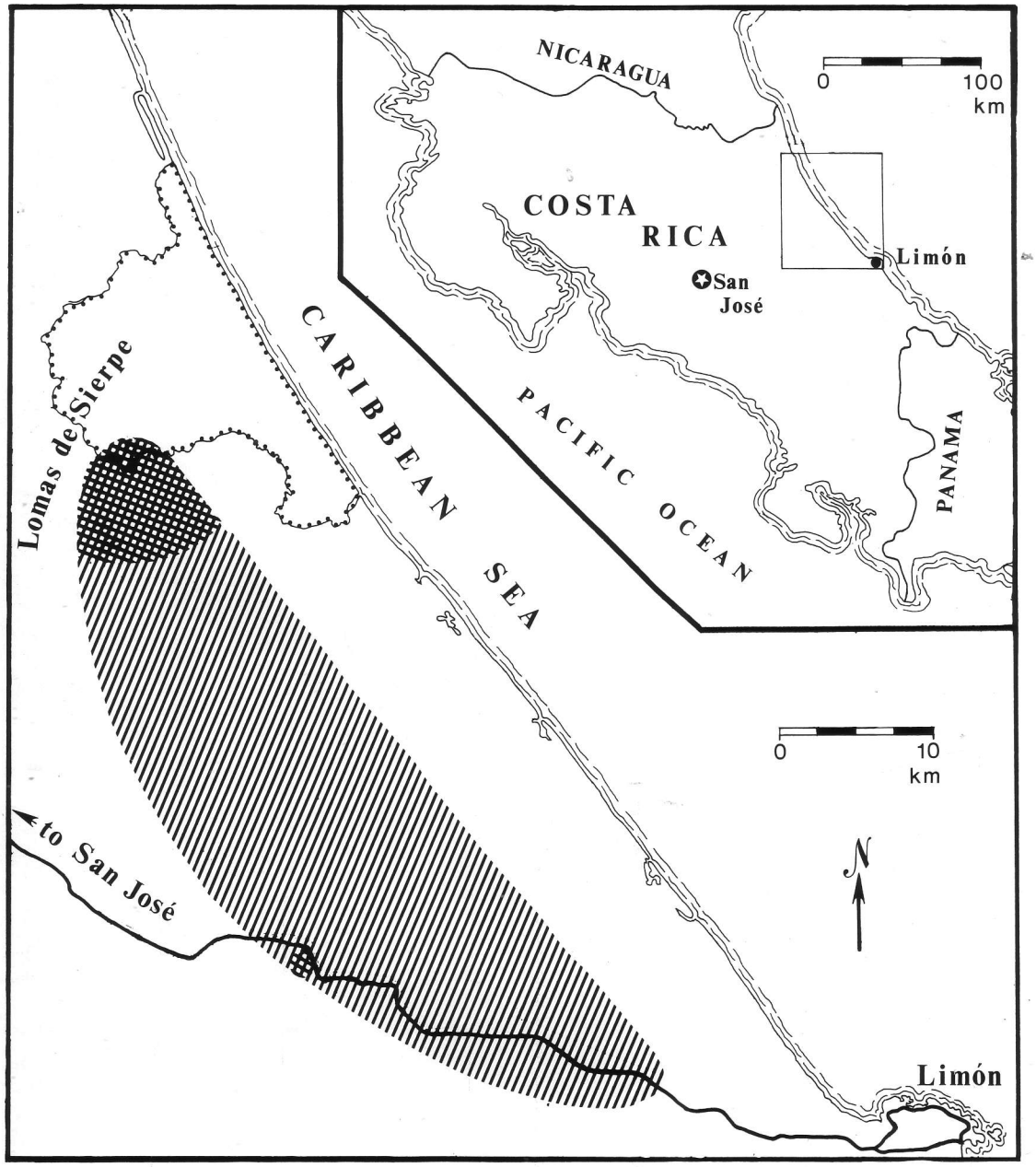
This species is characterized by typically large inflorescences with long first-order branches and rachillae, caducous rachis bracts, basal adventitious roots morphologically distinct from the root-spines above, leaves that are usually less deeply divided than in other species of *Cryosophila*, and fruits and seeds that are larger than in all other species except *C. macrocarpa*. *Cryosophila warscewiczii* is found at elevations from sea level to 1 200 m in lowland moist to wet forests on the Carribean slope from southern Nicaragua to central Panama, where its range crosses the isthmus to the Pacific coast. It has been reliably reported from northern Nicaragua, and presumably extends into southern Honduras (W. D. Stevens, personal communication).

This palm has been extirpated in many areas, but is still locally common throughout much of its historic range.

Cryosophila williamsii P. H. Allen (Fig. 22)

Ascending inflorescences with closely spaced peduncular-bract nodes are diagnostic for this species. Also characteristic are the consistently large number of veins per leaf segment. It is restricted to the steep limestone slopes of the Lago Yojoa watershed in west-central Honduras at an elevation of about 650 m.

Standley in 1930 described Lago Yojoa as "surrounded on all sides by lofty, heavily forested mountains whose sides remain untouched by man." The majority of this forest was still intact as recently as the mid-1970s (A. Molina, personal communication). Today, probably less than 5 km^2 of relatively undisturbed primary forest remain on the slopes surrounding Lago Yojoa below 1 000 m. In this small area this palm is common, with probably a few thousand adult individuals remaining. However, because of the extremely limited size of this area, if current deforestation rates continue, all remaining low-elevation Lago Yojoa watershed forest, including all known *C. williamsii*, will disappear by the end of this decade.



23. The present-day (cross-hatching) and approximated presumed historical (diagonal hatching) distributions of *Cryosophila cookii*. The dotted border outlines Tortuguero National Park, Costa Rica.

The Conservation Status of Cryosophila cookii

Cryosophila cookii was described by Bartlett (1935) based on a single collection made in 1903 from near the Río Hondo, on the Caribbean coast of Costa Rica (Fig. 23). It was not found again until 1988, when it was relocated at the type locality. Subsequently, it has been collected just south of Tortuguero National Park about 30–40 km northwest of the Río Hondo type locality.

Cryosophila cookii is most often known locally

as *súrtuba* although sometimes called *escobón*. Even though *C. cookii* is apparently not currently being used by local people, both common names suggest past use. The name *súrtuba* is occasionally used in other parts of Costa Rica for both *Cryosophila guagara* and *C. warscewiczii* (although both of these are more commonly called *guágara*) as well as several other palms (especially *Geonoma* spp.) that have bitter tasting palm hearts. *Escobón* ("large broom") presumably refers to the fact that *C. cookii* is the large *Cryosophila* relative to the sympatric *C. warscewiczii*. *C. cookii* is not known in cultivation, but occasionally is left standing when the forest is cleared (Fig. 24).

Cryosophila cookii occurs in Tropical Wet Forests as classified by the Holdridge system of tropical forest classification (Holdridge 1966, 1967), in a climatic zone characterized as being "very hot, very wet" (to over 6 000 mm of precipitation annually), without an annual water deficit during the dry season (starting in late December to early January and ending sometime in April) (Herrera 1985). A large portion of the geographic range of *C. cookii* is coincident with the only area of humic tropofibist histosol soils in Costa Rica [Gómez 1986 (=tropical bog forest *sensu* UNESCO (1973) according to Gómez)]. Although *C. cookii* is also found outside this area on other soil types, it may very well be edaphically limited, as it grows only on warm, dark and acidic soils with a high organic content, developed in water-saturated environments.

Within the area characterized by the above broad soil and climate types, *C. cookii* is further restricted to those low-lying areas (usually at elevations of less than 20 m) having very wet soil most of the year, yet never seasonally inundated. It has not been found on the hills or in the swamps common in the area.

Throughout its range, *C. cookii* occurs syntopically with *C. warscewiczii* (Fig. 2), a morphologically very different species with a considerably broader distribution [Panama to Nicaragua (Honduras?)]. In contrast to *C. cookii*, *C. warscewiczii* is a generalist species adapted to a wide variety of forest habitats. *C. warscewiczii* is found everywhere *C. cookii* occurs; within the range of *C. cookii*, *C. warscewiczii* also occurs on hilltops, slopes, and in seasonally inundated hollows. In other parts of its range, *C. warscewiczii* is found in drier habitats and up to about 1200 m elevation. *Cryosophila cookii* is a considerably less abundant species than *C. warscewiczii*. Although both species tend to have a patchy distribution with individuals occurring in well-defined populations, *C. cookii* populations are far smaller and much more widely separated. In a given area there may be as many as 100 individuals of *C. warscewiczii* for every one of *C. cookii*.

In the range of *C. cookii*, the rainy season typically begins in mid-April and ends around the beginning of January. It is usually divided into two parts by a relatively dry period in September. *Chryosophila cookii* apparently flowers continuously throughout the early portion of the rainy season, from April to August, producing about ten inflorescences sequentially. Fruits can still be found on trees at the end of the rainy season in late December. Typically, all the flowers of about half the inflorescences produced per year abort and fail to set fruit. Nothing is known about pollination or seed dispersal in *C. cookii*. However, *C. warscewiczii* is thought to be primarily pollinated by weevils (*Derelominus* sp.) (Henderson 1984), and seeds of *C. kalbreyeri* subsp. *cogolloi* in Colombia are thought to be dispersed by the Oilbird (*Steatornis caripensis*), which swallows the fruits whole, digests the pericarp, and then regurgitates the intact seeds (A. Cogollo, personal communication). Seeds were rarely encountered on the forest floor, even beneath trees bearing mature fruit. Seeds either rot quickly on the very wet forest floor or are soon taken by predators. Their germination rate is unknown (two attempts at germinating seeds in the laboratory failed), but recruitment is very low, as no seedlings and only two juveniles were ever encountered in the forest. Seedlings were found beneath a reproductive adult that had recently been felled, following which the area was burned. Therefore there is at least a limited seed bank, and removing the forest cover must be conducive to germination and/or rapid seedling growth in full sun.

Since *C. cookii* was known previously from only its type locality, it is not possible to determine with certainty its historic distribution. However, if, as suspected, *C. cookii* is limited by edaphic and various microhabitat requirements, the species was probably never much more widely distributed than it is today (Fig. 23).

Despite the relatively high level of environmental awareness and concern in Costa Rica, as reflected by the large amount of land under some form of protection (roughly 30% of the total land area, with about 10% in national parks), outside these protected areas (and too often, within) defor-

24. *Cryosophila cookii* left standing in cleared field, the typical habitat today for most of the surviving individuals of this species. Same plant as in Figure 10. 25. Martín Rojas Q., owner of the small farm bordering Tortuguero National Park, Costa Rica where the majority of the *Cryosophila cookii* remaining in intact forest are found.

estation is going on at a rate reported to be the highest per capita in the world (Myers 1989). In the vicinity of Tortuguero National Park (Fig. 23) this deforestation is such that the park will soon be an island of forest in a sea of cattle pastures and banana plantations, as clear-cutting is rapidly approaching the park from every landward direction, having already reached the park boundary in certain places. Ongoing deforestation is particularly acute west of the park, long an area of intense banana production. These immense corporate plantations are expanding rapidly as are smaller privately owned conversions, mainly for cattle ranching.

Despite the magnitude of deforestation outside the park, *C. cookii* could perhaps survive indefinitely, if there were a viable population within the park. Unfortunately, that does not appear to be the case. Although there is a fairly healthy population in a small forested area just south of the park border across the Río Sierpe, I was able to locate only one adult *C. cookii* (Fig. 9) within the park (in the vicinity of the abandoned Río Sierpe guard station) during a 1-wk search. The apparent reason for this is that there is a fairly abrupt change in habitat from south of the Río Sierpe to within the park. Just north of the river, conditions abruptly become too wet (to the east) or too hilly (to the north and west) for the specialized *C. cookii*. In another search near the Agua Buena Park Station, north of the ridge of hills (Lomas de Sierpe) that bisects the park southwest to northeast, I found no *C. cookii*, although *C. warscewiczii* is common.

As indicated previously, I estimate the present population size of *C. cookii* to be only about 100 adults. Although a crude estimate, I feel this accurately reflects the seriousness of the situation. That is, even if the estimate is, in reality, several times too low, it still does not change the overall picture relative to the chances of long-term survival for this species. Also, it must be remembered that as more and more land is cleared and individuals lost, the remaining plants are becoming increasingly isolated from one another, often as single individuals left standing in cleared fields (Fig. 24). Consequently, effective population size is, in terms of successful pollination rate (*Cryosophila*, although bisexual, are self-incompatible) and likelihood of seedling survival (essentially zero in the cleared fields) undoubtedly much lower than actual population size.

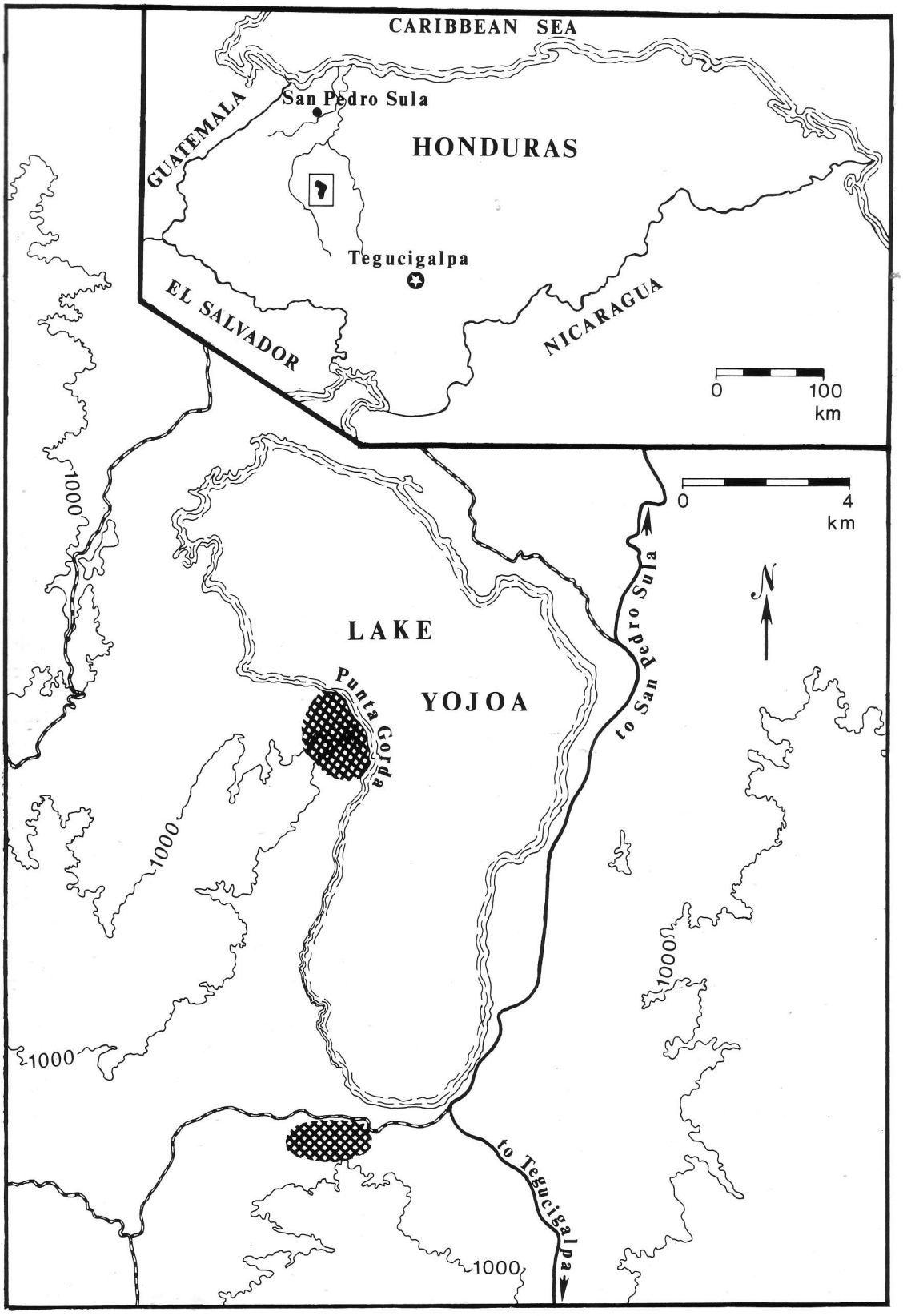
Since the key to saving *C. cookii* lies in protecting at least one viable wild population, I suggest that an exhaustive search for individuals be made within Tortuguero National Park, concentrating in the area to the east of the old Río Sierpe Park Station, just north of the Río Sierpe. This survey should be carried out at the height of the dry season (around March), since much of the forest in this area is flooded for the greater portion of the rainy season.

If, as I suspect, a viable *C. cookii* population does not occur in the park, perhaps the only other hope for preserving this species in the wild is to bring land south of the park, which is known to contain a stable population of *C. cookii*, into the park system. Adjacent to the present park boundary is a small (approximately 200 ha) private farm, which is still mostly forested and contains numerous adult *C. cookii*. The owner (Fig. 25) bemoans the disappearance of essentially all the forest outside the park surrounding his land, and he is very concerned that unless his land is incorporated into the park, it too will be cleared soon after he is gone. Adding this small piece of property to Tortugurero National Park could be the best and perhaps only opportunity for preventing the likely imminent extinction of *C. cookii*. Furthermore, as a result of the abrupt habitat change at the park boundary (the Río Sierpe) such a modest park expansion could very well be adding to the park a number of species other than *C. cookii* that are currently rare or absent inside the park.

At the very least, an effort should be made to collect seed (mature from June to December) in order to try to bring *C. cookii* into cultivation. The Río Hondo type locality is very accessible from San José (one individual being visible from the San José to Limón highway). This distinctive palm has potential as an ornamental, despite its spininess. Unfortunately, collecting mature seeds is difficult because they are rarely encountered on the ground, and collecting infructescences from these tall, extremely spiny palms is very difficult (and only a small fraction of the fruits are mature at any given time).

The Conservation Status of Cryosophila williamsii

Paul Allen described *Cryosophila williamsii* in 1953 based on his own 1952 collection from Punta Gorda on Lago Yojoa in west-central Honduras (Figs. 26,27). It was recollected at the type locality


CARIBBEAN SEA
GUATEMALA
San Pedro Sula
HONDURAS
Tegucigalpa
EL SALVADOR
NICARAGUA
0
100
km
0
4
km
N
LAKE
YOJOA
Punta Gorda
to San Pedro Sula
to Tegucigalpa
1000
1000
1000
1000
1000

in 1987, and in 1990 was first collected from an area immediately south of the lake.

Allen (1953) reported that *C. williamsii* was known locally as *mojarilla*, but I found no one in the Lago Yojoa area who recognized this name. Rather, it was most commonly called *palmiche* or simply *palmera*. Like most species of *Cryosophila*, *C. williamsii* leaves were formerly used for thatch (Allen 1953), although apparently they no longer are. The palm heart is apparently eaten, as numerous felled individuals were encountered in which the "heart" had been removed.

Lago Yojoa, the only large natural lake in Honduras, lies at 635 m elevation between the valleys of the Otoro-Ulua rivers and the Humuya-Comayagua rivers in west-central Honduras. To the west, south and southwest of the lake, the land rises abruptly up the very steep and rugged, limestone boulder strewn slopes, soon reaching an elevation of over 2 000 m. After a slight rise in elevation north of the lake, there is a gradual descent along the Ulua River valley to the Caribbean.

According to the Holdridge Life Zone System (Holdridge 1966, 1967), the Yojoa watershed area below 1 500 m is classified as Very Humid Subtropical. However, such a broad category masks numerous habitat differences in the area resulting from varying weather patterns, topography, and elevation. For example, precipitation is greatest (to over 3 000 mm annually) along the western, southern, and eastern slopes above the lake, as northerly winds from the Caribbean pick up additional moisture over the lake, which is then deposited on these slopes. This high rainfall on these relatively low-elevation, steep limestone slopes has resulted in a habitat type unique in Honduras, and undoubtedly explains the extremely restricted distribution of *C. williamsii*. Although the flora of the Lago Yojoa watershed area is poorly known, it very probably harbors other local endemics.

Cryosophila williamsii is known from only two localities around Lago Yojoa (Fig. 26). Although the upper elevation limit of *C. williamsii* is unknown, species of *Cryosophila* rarely occur above 1 000 m. This elevation contour is included in Fig. 26, in order to demonstrate what the historical distribution might have been. Unfortunately, the only forests remaining below 1 000 m are a small patch on Punta Gorda and an even smaller area along the slopes south of the lake.

27. Punta Gorda, Lago Yojoa, Honduras. Site of the last known viable population of *Cryosophila williamsii*.

As reported by Allen (1953), *C. williamsii* was very common in the primary forests of Lago Yojoa. Within the small area of remaining intact forest, this is still true today. This situation contrasts with that of *C. cookii*, a much less common species within its forest habitat. Similar to *C. cookii*, individuals of *C. williamsii* apparently flower continuously during the rainy season from August to December. Fruits are probably still present on trees in March and perhaps even April. Nothing is known about pollination and seed dispersal of *C. williamsii*. Seedlings and juveniles are common, and germination and recruitment rates must therefore be high.

On account of habitat specificity, *C. williamsii*, like *C. cookii*, was probably never much more geographically widespread than it is today, but this likewise cannot be confirmed from herbarium records.

More than half of Honduras's 112 088 km^2 is still forested (Myers 1980, 1989; Lanly 1982; FAO 1988). However, the overwhelming majority of these forests are concentrated in the very remote eastern third of the country, the "Mosquito Coast" area, comprising the eastern portions of Colón and Olancho Departments and the entire Department of Gracias a Dios. Approximately 90 000 ha of Honduran forest are destroyed annually (Myers 1989). As indicated above, only about 500 ha of

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26. The distribution of *Cryosophila williamsii*. The present-day distribution is indicated by cross-hatching and the lakeward slopes below the 1 000-m contours approximate the presumed historical range of the species.

forest containing *C. williamsii* remain surrounding Lago Yojoa.

Extrapolating, as for *C. cookii*, from estimated population density and area of intact forest, I estimate a total population size of a few thousand remaining individuals of *C. williamsii*. Even though this is considerably (by at least an order of magnitude) larger than the estimate for *C. cookii*, of the two species *C. williamsii* is probably in the most immediate danger of becoming extinct because of its more restricted distribution.

In contrast to the factors affecting primary forest in the range of *C. cookii*, deforestation in the Lago Yojoa area is generally due to small scale "slash and burn" subsistence agriculture (mainly corn). As previously indicated, an additional threat to *C. williamsii* is the selective felling of individuals, presumably in order to collect the palm heart.

The entire Lago Yojoa watershed area was declared a forest reserve in 1971. Unfortunately, this designation is meaningless in reality, as most of the deforestation in the area has occurred since that time.

A thorough demographic survey of remaining *C. williamsii* is needed. The Lago Yojoa watershed, as well as surrounding areas away from the lake, should be included, in order to accurately assess current population size. Since *C. williamsii* is also unknown in cultivation, efforts should be made to collect seeds for introduction into the horticultural trade. Because of its smaller size and fewer spines, *C. williamsii* has greater potential as an ornamental than does *C. cookii*.

The difficulty in proposing a meaningful conservation strategy for the preservation of *Cryosophila williamsii* is that the government of Honduras has already recognized the significance of the Lago Yojoa area, having designated the watershed a reserve. The fact that the area has now been identified as harboring at least one Honduran endemic (and I suspect numerous others) could bolster the argument for upgrading the protection status of the remaining forest (e.g., to some sort of "biological refuge" or "scientific reserve") so as to at least increase the chances for real protection.

Either *C. cookii* or *C. williamsii* could easily become the first example of the contemporary extinction of a neotropical palm species. The precarious situations of both species result from their small population sizes and the rates of deforestation occurring in the very small area of suitable habitat still remaining. It is very difficult to argue for the preservation of single species from a biological standpoint, except perhaps when the species are genetically isolated (i.e., as in a monotypic genus). Therefore it should be reemphasized that by protecting the specialized habitats of *C. cookii* and *C. williamsii*, undoubtedly numerous other localized endemics (such as *Arberella costaricensis*, a localized bamboo known only from the area of the type locality of *C. cookii*) will also be protected, since it would be expected that species in other plant groups would also have become adapted to the same localized environmental conditions that help explain the historically restricted distributions of *C. cookii* and *C. williamsii*.

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LITERATURE CITED

ALLEN, P. H. 1953. Two new fan palms from Central America. Wrightia 1: 53–60.

BARTLETT, H. 1935. Botany of the Maya Area: Miscellaneous Papers. II Various Palmae Corypheae of Central America and Mexico. Publ. Carneg. Inst. Wash. 461: 29–41.

BLUME, K. L. 1838–1839 ["1836"]. De Aliis Quibusdam Coryphinis Indiae Orientalis. Rumphia 2: 53.

DRANSFIELD, J. 1978. Growth forms of rain forest palms. *In:* P. B. Tomlinson and M. H. Zimmermann (eds.), Tropical trees as living systems, pp. 247–268. Cambridge University Press, New York.

DRANSFIELD, J., D. JOHNSON, AND H. SYNGE. 1988. The Palms of the New World. A Conservation Census. IUCN, Gland, Switzerland.

EVANS, R. J. 1995. Systematics of *Cryosophila* (Palmae). Syst. Bot. Monogr. 46: 1–70.

FAO (FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS). 1988. An interim report on the state of forest resources in the developing countries. Forest Resources Division, Forest Department, FAO July Misc., Rome.

GÓMEZ, L. D. 1986. Vegetación de Costa Rica. Apuntes para una biogeografía costarricense. *In:* L. D. Gómez (ed.), Vegetación y Clima de Costa Rica, Vol. 2. Editorial Universidad Estatal Distancia, San José, Costa Rica.

GOOD, R. 1974. The geography of the flowering plants. Longman, London.

HENDERSON, A. 1984. Observations on pollination of *Cryosophila albida*. Principes 28: 120–126.

HERRERA, W. 1985. Clima de Costa Rica. *In:* L. D. Gómez (ed.), Vegetación y Clima de Costa Rica, Vol. 1. Editorial Universidad Estatal Distancia, San José, Costa Rica.

HOLDRIDGE, L. R. 1966. The life zone system. Adansonia 6(2): 199–203.

———. 1967. Life zone ecology. Tropical Science Center, San José, Costa Rica.

JOHNSON, D. V. 1986. Economic Botany and Threatened Species of the Palm Family in Latin America and the Caribbean. Final Report WWF 3327.

———. 1987. Conservation status of wild palms in Latin America and the Caribbean. Principes 31: 96–97.

———. 1988. Worldwide endangerment of useful palms. *In:* M. J. Balick (ed.), The palm—tree of life: biology, utilization and conservation. Adv. Econ. Bot. 6: 268–273.

LANLY, J.-P. 1982. Tropical forest resources. FAO For. Pap. No. 30, Rome.

MYERS, N. 1980. Conversion of tropical moist forests. National Academy of Sciences, Washington, D.C.

———. 1984. The primary source: tropical forests and our future. W. W. Norton & Co., New York.

———. 1989. Deforestation rates in tropical countries and their climatic implications. Friends of the Earth, London.

STANDLEY, P. C. 1930. The woody plants of Siguatepeque, Honduras. J. Arnold Arbor. 11: 15–46.

UHL, N. W., J. DRANSFIELD, J. I. DAVIS, M. A. LUCKOW, K. S. HANSEN, AND J. J. DOYLE. 1995. Phylogenetic relationships among palms: cladistic analyses of morphological and chloroplast restriction site variation. *In:* P. J. Rudall, P. J. Cribb, D. F. Cutler, and C. J. Humphries (eds.), Monocotyledons: systematics and evolution, pp. 623–662. Royal Botanic Gardens, Kew.

UNESCO (UNITED NATIONS EDUCATIONAL, SCIENTIFIC, AND CULTURAL ORGANIZATION). 1973. International Classification and Mapping of Vegetation. UNESCO Ecology and Conservation Ser. No. 6, Paris.

Addendum

A number of cultivated, fertile *Cryosophila williamsii* were recently (April 1996) discovered in the town of Sesesmil, Honduras near the Guatemalan border about 10 km north of Copán Ruinas. The original plantings were said to have been made about 25 years ago from seeds collected in the forested hills nearby. The palm is known locally as amargo ("bitter"), but wild individuals are extremely rare today as they are sought out for their highly desirable, albeit bitter tasting, palm hearts. In fact, no wild adults are known to still occur in the vicinity, and a search turned up only two (5–10 years old?) juveniles. These too will undoubtedly be cut as soon as they are larger.

The significance of this recent discovery is that the geographical distribution of *Cryosophila williamsii* is considerably greater than previously thought. Sesesmil is approximately 120 km west of Lago Yojoa, and presumably *C. williamsii* occurs, or at least did occur, in the intervening area between these two disjunct populations. In addition, the proximity of Sesesmil to the Guatemalan border argues for the occurrence of *C. williamsii* in extreme eastern Guatemala. Lastly, since the two wild, juvenile *C. williamsii* encountered were not growing on limestone, this species is obviously not restricted to this habitat type as previously presumed.

Although *Cryosophila williamsii* is now known to be much more widely distributed geographically than previously realized, I do not think this significantly changes the conservation status of the species. It still must be considered extremely endangered, particularly since no viable populations are yet known to occur outside the Lago Yojoa area.