

Conservation of the endemic overexploited cycad, *Cycas circinalis* L., in the Nilgiri Biosphere Reserve, South India

Final Report Submitted to TCS

Summary:

Cycas circinalis L., endemic to South India, is heavily harvested for its pith, male cones, leaves and fruits for both local and commercial use. A pilot study carried out in the Nilgiri Biosphere Reserve (NBR), Western Ghats, confirmed the high threats to which *C. circinalis* populations are subject. This project brought together information necessary to design a strategy for effective conservation through research on life history, harvest impacts, extent of trade and propagation potential. A conservation plan which for the species has been developed through this project and is currently being implemented by Keystone Foundation, a non-governmental organization that has more than fifteen years of experience in the field of conservation and livelihoods.

Introduction:

The project 'Conservation of the endemic overexploited cycad, *Cycas circinalis* L., in the Nilgiri Biosphere Reserve, South India' was supported by The Cycad Society with a grant to Keystone Foundation and in collaboration with Dr. Tamara Ticktin of the University of Hawaii and People and Plants International for a period of one year. Keystone Foundation had already conducted intensive surveys and initiated conservation outreach work on *Cycas circinalis* from 2006 onwards.

C. circinalis is endemic to the Western Ghats and hilly regions of the southern peninsula of India, in the states of Kerala, Karnataka, Tamil Nadu, and the south of Maharashtra (Jones 2002). It is arborescent, growing up to 8 m tall, with leaves that are about 1.5-2.5 m long. It is usually found in fairly dense, seasonally dry scrubby woodlands in hilly areas. Male cones are orange, 60-90 cm long x 20-25 cm wide. Seeds are ovoid to subglobose, up to 4 cm long, with red-yellow sarcotesta. To our knowledge, there are no published studies on any aspect of the life-history or ecology of this species.

The Nilgiri Biosphere Reserve (NBR) is part of the Western Ghats mountain chain, a biodiversity hotspot (Meyers et al. 2002). It was the first Biosphere established in India, declared by UNESCO in 1986. It lies between 10° 45' N to 12° N and 76° E to 77° 15' E with a total area of 5520 sq. kms spread across the three south Indian states of Karnataka, Kerala and Tamil Nadu. Altitude varies from 250m to 2650m. The NBR is also home to a large number of different indigenous communities, their total population numbering about 200,000.

Our pilot study provided identification of the threats to which *C. circinalis* is subject and assessed the structure of populations subject to different types of harvest in 15, 20x 20 m plots located across nine regions of the NBR. We found that *C. circinalis* fruits and young leaves are harvested by indigenous communities in the NBR for food, and in Kerala the seeds are heavily harvested and sold locally as medicine. The stems (pith) and male cones are extracted by outside harvesters (i.e. not from local communities) and traded as medicines in regional and national

markets. In Tamil Nadu the mature leaves are very heavily harvested by outside harvesters for the floriculture industry. Leaf-harvested populations showed low levels of recruitment and high adult mortality. In these populations, 92% of all individuals > 20 cm high were harvested for their leaves, and $91.3 \pm 15\%$ of all leaves per tree were harvested. Stem-harvested populations showed clear signs of overexploitation, being devoid of all individuals > 50 cm high. We estimated that these cycads could take up 15-20 years to begin to reproduce and that they become of harvestable size for their pith once they are about 50 years old.

The pilot study confirmed the need to further monitor populations of *Cycas circinalis* closely and to begin an outreach program that spread awareness on the need to conserve and propagate the species. The following were the objectives of the study:

1. Identify monthly leafing & fruiting phenology and harvest rates
2. Assess demographic rates and population growth/decline of *C. circinalis* populations subject to different types of exploitation.
3. Assess the conservation status of *C. circinalis* over a larger area
4. Promote and test the potential for germination and outplanting of seedlings
5. Use the above information to design a strategy for better conservation.

Objectives 1 & 2 were achieved by assessing the status of *C. circinalis* populations, identifying effects of seed, leaf and pith harvest on population structure and documenting phenology patterns. Harvest had a significant impact on population structure with leaf and pith harvested populations lacking large individuals. Timing and levels of leaf production differed significantly across sites, with sites with higher rainfall having more frequent leaf production. This suggests variation in resilience to harvest across regions. Our results highlight the importance of protecting the remaining populations of this multi-use species.

Population size, structure and impacts of harvest

To assess the status of *C. circinalis* we estimated the density of existing populations and calculated their population structure in 12 study sites. We randomly established one 20 x 20 m permanent plot within each population. In each plot, all *C. circinalis* plants of all sizes were counted and tagged. For each individual girth at breast height (GBH), height, number of whole leaves, number of cut leaves, number of leaf scars, number of branches, and reproductive status were recorded. To assess the impacts of harvest on population size structure, individuals in populations subject to the same type of harvest were summed and the height-class structure of each was calculated and compared using log-linear analyses. Populations of the same harvest type were summed as opposed to averaged given the low density of *C. circinalis* individuals per population.

Leaf phenology and rates of leaf production at select sites

We selected four leaf-harvested *C. circinalis* sites for a more detailed study of phenology and the rates and timing of leaf production and harvest. The sites represent varying environmental conditions and intensities of leaf harvest. At each of these locations, we randomly selected between 5 and 7 adult individuals for study. Focal plants were at least 5-10m apart. We

monitored a total of 33 stems on 22 individuals between February 2007 and September 2008. Monthly measurements included the number of leaves produced and harvested, plant height and girth, and the presence of reproductive structures. All sites have a history of seed harvest in addition to leaf harvest. However, during the study period, no seed harvest was observed at the sites. In addition, seed harvest is not expected to affect the factors measured. In some months, the sites were inaccessible due to weather or wildlife. We used correlation analysis to test for associations between rates of leaf production and leaf harvest. We used analysis of covariance (ANCOVA) to test for differences in leaf production between sites, with plant size (maximum leaf number) as a covariate. The maximum number of leaves present was used as an indicator of plant size because measures of plant height were unreliable due to land slides and multiple-stemmed individuals. Leaf production was cube-root transformed to improve normality and plants that had no leaves for the duration of the study were omitted. A short research article with the methods and results has been submitted to TCS and will be published shortly in the newsletter.

Preliminary Results

C. circinalis size class distribution and density varied greatly across sites. Most populations were very small and more than half (7/11) showed a near or total lack of individuals in the larger size classes.

On average 86.6 percent of leaves per whorl were removed from harvested individuals, ranging from 72.3 percent at one site to 89.8 percent at another. Across the three sites where harvest occurred included in the 2007-2008 phenology study, 86.3 percent of cycad stems with leaves were harvested for their leaves, with a total of 46.2 percent of leaves harvested over the course of the study. No leaves were harvested from any plant in one of the sites during the study period. This may be due to the small size of the plants at the site, or the sites' inaccessibility. Leaf harvest occurred primarily in March, prior to the major flush of new leaves in May in the site located in the western part of the NBR. Harvest of leaves occurred primarily in December, a few months before a new flush of leaves began emerging in the eastern part of the NBR. However, in the site that was located in the south eastern part of the NBR did not have a primary period of harvest. Instead, individual plants were harvested throughout the year. Across all sites, we found a significant positive correlation between the number of leaves produced and the number of leaves harvested ($R=0.7230$, $p=2.0 \times 10^{-6}$). No cone, seed or pith harvest was observed during the study period at these sites.

Twenty four percent of observed stems (8 of 33) in the phenology study did not produce any leaves during the study period, including four stems that had no leaves for the duration of the study. We observed reproduction only at the one site. Of seven individuals monitored, one individual produced seeds and two produced cones. Differences in the timing of leaf production among the four sites appear to be related to environmental differences. Plants at 2 sites which receive similar amounts of precipitation, produced a single flush of leaves during the summer months. In contrast, to the site that has a longer monsoon season and receives approximately three times the amount of precipitation. Plants at this site continue producing leaves throughout the year, after a primary flush in May. The pattern is less clear in one site, where individual plants only produced leaves once per year, but leaf production did not occur synchronously

across the population. Across all four sites, stems with a greater number of leaves produced more leaves during the study period (Figure 7, $p < 0.001$, $F = 90.12$, $df = 1, 24$). *C. circinalis* stems at the western NBR site produced more leaves than *C. circinalis* stems of a comparable size at the three other sites (pre-planned contrast, $p = 0.0005$, $t = -3.087$). The other three sites are not significantly different from each other. When leaf production is summed across stems for each plant, the effect of site on leaf production is marginally significant ($p = 0.059$, $F = 60.54$, $df = 3, 16$).

Our analyses of population structure suggest that the decline in *C. circinalis* populations may be due, at least in part, to heavy harvest of pith and leaves, as population subject to these types of harvest showed a near total lack of adult individuals. Other cycads have been found to be able to tolerate annual harvest of less than 5 % of adults. This is likely much less than current rates of pith harvest in Tamil Nadu, where stem-harvesters tend to harvest all individuals in a population > 50 cm height. In terms of leaf-harvested populations, given the very high rates of leaf harvest we documented, the lack of individuals in the largest size-class likely represents elevated mortality of older individuals as a result of consistent leaf-harvest over time.

The significant positive correlation we found between rates of leaf harvest and leaf production suggests that leaf harvest may increase rates of leaf production at the expense of other functions. Alternately this relationship may be a result of increased leaf production allowing collectors to harvest greater quantities of leaves. Without unharvested control plants at each of our sites, we are currently unable to differentiate between these two possibilities.

The impacts of harvest of *C. circinalis* leaves, and therefore the potential for sustainability, may vary due to differences across sites in climate and in plant phenology. One critical factor that can greatly alter the impacts of leaf harvest is the timing of harvest. *C. circinalis* leaves are produced in flushes which senesce and are shed naturally, therefore harvest soon before the leaves are shed at the end of the leaves' natural lifespan could have little impact as compared to harvest soon after leaf production. Because of high levels of harvest, we were not able to identify a sufficient number of comparable unharvested plants within each site and therefore cannot differentiate between the effects of environmental conditions, such as precipitation, and the effects of leaf harvest intensity on leaf production. Based on our observations, rates of leaf production may also differ depending on whether new, young leaves or mature, fully expanded leaves are harvested. Our results point to the importance of more detailed phenology studies to better clarify these relationships.

Objective 3 to assess the status of the population over its whole distribution was followed up by Vandana Krishnamurthy (Doctoral student at the University of Hawaii). Vandana located populations across the western ghats at the following sites:

Melkote Temple Wildlife Sanctuary -The Melkote Temple Wildlife Sanctuary is located in Melkote, Mandya District, Karnataka. The Sanctuary surrounds the Melkote temple, created mainly to protect the wolf. The altitude here varies from 880 to 1127 m. Temperatures range from 17° to 38°C, and the mean annual rainfall is 700 mm. Forest type in the Melkote Temple wildlife Sanctuary vary from dry deciduous to scrub forests. The other mammals found in this sanctuary are jungle cat, leopard, bonnet macaque, langur and pangolin.

There has been some ambiguity in the taxonomy of this species in the past two years. It was called *Cycas circinalis* until last year. Since the morphology is very different from other individuals of *Cycas circinalis* found Along the Western Ghats this species was named as *Cycas indica* (refer to paper by Lindstrom and Hill, 2007). However, it is not completely certain, since there are doubts that the species is also called *Cycas swamyii*. The forests in the Melkote Temple Wildlife Sanctuary are mostly of the open canopy type, which makes access to the *C.circinalis* very easy. Harvests in these areas are intense over the past years. Leaves are extensively harvested for sale to the floriculture industry (personal communication). The difference in the morphology of the species could also be because of the stress due to harvest. The different areas sampled were Uligere, Rampura and Doddarehalla.

Indira Gandhi Wildlife Sanctuary and National Park -The Indira Gandhi Wildlife Sanctuary and National Park is a protected area which lies in the state of Tamil Nadu state in South India. It is often called *Topslip*, a village in the northeast corner of the park which is the main visitor center. The mean annual rainfall is between 500mm in the south western fringes to 5000mm on the north east. Altitude ranges from 340m to 2,510m and annual rainfall varies between 800 mm to 4500 mm. The forest type ranges from wet evergreen, sub-tropical evergreen, moist deciduous, dry deciduous, semi-evergreen and montane-shola grasslands. The terrain here is thickly wooded hills, plateaus, deep valleys and rolling grasslands. *Cycas circinalis* is found in the teak plantation areas as well as in the sanctuary area. Harvest does occur, however in very small quantities mainly for marriage celebrations. The teak plantations had individuals very close together, probably cohorts of same age individuals. The areas sampled were Amballi, Ala Marad Parai, Palamarada, Duvanam and Srichali. Of these Duvanam and Srichali are teak plantation areas.

Peppara Wildlife Sanctuary - Peppara Sanctuary is part of the Agasthyamala Biosphere Reserve (ABR) which borders parts of Kerala and Tamil Nadu in South India lying at the southern end of the Western Ghats. The Agasthyamala Biosphere Reserve includes moist deciduous forests, montane rain forests and Shola. IUCN has identified Agasthyamala and its environs as one among the three important mega centres of diversity within India which needs immediate conservation. The sampling was conducted at the Peppara wildlife Sanctuary. The topography of the Peppara Wildlife Sanctuary is hilly with an elevation varying from 100 m to 1717m. This sanctuary has tropical, evergreen and deciduous forests, and the hilly parts of the sanctuary harbor tropical forests. Only one population of *Cycas circinalis* was sampled in the Peppara Sanctuary area found close to human habitation within an *Areca* plantation. The local people harvest the seeds for consumption in these areas. There are more populations in this area which could not be sampled due to logistical reasons. Since, we sampled only one site we have named it the Peppara Sanctuary.

Silent valley National Park - Silent Valley National Park is located in the Nilgiri Hills, Palakkad district, Kerala, in South India. It is part of the Western Ghats. The altitude of the park ranges from 658 m to 2328 m. The forest type in this region is of the montane rain forests and tropical moist evergreen type. The average temperature in Silent valley is 30°C and rainfall is 1624.3 mm. Soils are blackish and slightly acidic in evergreen forests where there is good accumulation of organic matter.

Cycas circinalis grows largely in the buffer zones of the national park, however populations are also found in the core of the park. The buffer zone consists of teak plantations. The ground vegetation mainly consists of teak saplings and some vegetation that includes *C.circinalis*. We sampled two population of *C.circinalis* in the Plantation area, recorded as Plantation1 and Plantation2. The areas sampled in the forest core were Panachola 1 and Panachola 2. The sites were selected to cover *C.circinalis* populations in the plantations as well as forested areas.

Methods - The study was divided into three phases:

1. Collection of population data
2. Habitat analysis
3. Questionnaire surveys

Collection of population data: In each of the *C.circinalis* habitats 20X20 meter plots were laid out depending on the spread of the individual plants. In these plots the individuals were marked using a GPS. Parameters like type of distribution, number of adults and juveniles (adults with stem, juveniles without stem), height of each tree, girth of each tree, number of leaves, length of the longest leaf on each individual, length of the shortest leaf on each individual, number of individuals in fruiting or flowering, size of the cone, number of seeds in the fruit, presence of harvest and type of harvest were measured in each of the plots

Habitat analysis: Apart from measuring individual plants the habitats were rated for the weeds/exotics/invasive plants, grazing and anthropogenic pressures (fuel wood removal, clearing of litter and harvest of plant products) as 1-absent, 2-disturbed and 3-highly disturbed.

Questionnaire surveys: Indigenous people who harvest the plant products for personal use and middle men and markets sellers who harvest *Cycas circinalis* for commercial purposes were interviewed regarding consumption and trade.

Preliminary Results- Our research suggest that the status of *C. circinalis* populations in the Tamil Nadu portion of the Western Ghats appears to be poor as most populations have few individuals and lack adult plants. While we do not have historical data on the populations we monitored, *C. circinalis* traders and harvesters report that many populations have disappeared, and other studies (FRLHT, 2006) has estimated a reduction in *C. circinalis* populations of > 50% in Tamil Nadu. Our results indicate that this decline is likely continuing. However in Kerala the status of *C. circinalis* may be better than suggested by our results as this species is also found growing in home gardens and along roads. A more detailed article on the western ghats survey is currently being prepared and will be submitted to TCS for publication in their newsletter shortly.

Besides the surveys in the Western Ghats, we were in touch with the NTFP-EP, India a network of practitioners in which Keystone Foundation plays a significant role. Through the network we sent out pictures of the plant and posters about it to various partners and asked them to get in touch with any information they may have of the plant. The group from Sirsi in the Western Ghats was aware of its presence but not about its uses. Thereafter a packet of seeds was sent to them to raise in their forest nurseries. The partners on the eastern side of the peninsula replied from Orissa and Andhra Pradesh with news of other Cycad populations and people's use of the

same. Madhu Ramnath who is the co-ordinator of the India program has been keenly following up with the groups and we hope to do intensive surveys and help locate the status of the Cycad populations in these areas.

Objective 4 has been an area of strength for Keystone since we have a program of forest species nurseries since 1998. These nurseries are based in villages and have a mandate to raise agricultural and forest species that are needed for a village towards their fuel wood, fodder, fibre, construction, food etc needs. The nurseries source seeds from the local areas and are looked after by a few families within the same village. The nurseries produce plants for the needs of the village, for planting in village lands or in forest lands as part of afforestation programs. The nurseries also identify through interviews and discussions with the local people special plants or trees that have been reported in low populations or over exploited. These plants are then brought into the nursery program, seeds are procured and sapling raised for distribution or sale.

Cycas circinalis seeds were first procured from the forests around the Velleri combei village and subsequently raised in the nursery there. Initial germination rates were very poor. Only between 20-30% of seeds germinated. L.Rajendran who supervises the nurseries then started to take more interest in the germination rates and tried experimenting with various treatments before the seeds were planted. Some of the methods that met with better success rates were-

Method 1- Burying the seeds in sand for 2-3 weeks and then transplanting them to bags. This method gave more than 50% germination rates

Method 2- Soaking the seeds in cowdung water for 10 days before transplanting to bags. This method yielded more than 50% germination rates.

More than 2000 seeds were collected in 2007 from the Nilambur area and these were planted in the village nursery and 500 were planted separately in the area nursery. Of the 500 seeds more than 80% germinated and have been raised. Of the 2000 seeds we got close to 60% germination only and this may have had to do with the overall maintenance and upkeep of the nursery and also the quality of the soil used. In Kotagiri nurseries 1000 seeds were germinated. Plants were supplied for sale and also out planted in the village lands at Velleri combei and Samaigudal. The survival rate will be monitored in the years to come.

Implications for conservation

Most *C. circinalis* populations are subject to different combinations and levels of leaf, pith and seed harvest, both by local communities and outside harvesters. Our results suggest that heavy harvest of leaves, whether for the floriculture industry and/or for local rituals, and harvest of pith, appear to be negatively impacting populations. These effects are likely compounded by habitat loss and potentially other factors such as climate change. Efforts to find substitutes for the floriculture industry may decrease leaf harvest of wild populations, but not pith harvest which is sold as medicine. An approach being initiated by the Keystone Foundation is the establishment of “Cycad conservation centers” which integrates community-based monitoring, local propagation and value addition to local communities. Planting on-site and in nurseries is needed to increase the feasibility of sustainable harvest in cultivation and preservation of this species in the wild. Research and conservation measures driven by local communities are key to adapting management plans for the sustainable use of this endemic species.

Acknowledgements

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THE CYCAS SOCIETY
2007-08

S.No	Budget Head	Budget	Total Exp	Balance
1	Monitoring-Phenology	4,000.00	3,000.00	1,000.00
2	Monitoring-Permanent Plots	6,000.00	3,872.50	2,127.50
3	Western Ghat Assessment	54,000.00	59,783.00	(5,783.00)
4	Nursery	5,000.00	2,843.50	2,156.50
5	Documentation	23,000.00	22,430.00	570.00
		92,000.00	91,929.00	71.00

Funds Received **91,929.00**

Less: Expenses **91,929.00**

Balance of Funds **-**