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## DISCOVERY OF A NEW SUB-POPULATION, MAPPING AND UPDATED RED LIST ASSESSMENT OF THE ENDANGERED *CYCAS BEDDOMEI* DYER (CYCADALES: CYCADACEAE)

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### OPEN ACCESS

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**Abstract:** A new sub-population of *Cycas beddomei* Dyer (Cycadaceae), hitherto believed to be endemic to the Seshachalam Hills (Tirupati-Kadapa Hills) of Andhra Pradesh is discovered from Velikonda Hills (Nellore-Kadapa districts) of Andhra Pradesh. Hence its global distribution status is hereby revised endemic to Seshachalam and Velikonda hills of Eastern Ghats of Andhra Pradesh. Combined datasets of our earlier studies with the latest indicated no change in its 'Endangered' status.

**Keywords:** Beddome's Cycad, Endangered, endemism, restricted distribution, updated IUCN Red List assessment.



*Cycas beddomei*  
Beddome's Cycad



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## INTRODUCTION

Cycads, often referred to as 'living fossils', comprising 11 genera and 307 species, of which 98 species are classified under the family Cycadaceae, represent a single genus *Cycas*. About 63% of cycads are threatened (IUCN 2014). In India, the genus *Cycas* is represented by nine species (Singh & Khuraijam 2014), of which *Cycas beddomei* Dyer (Thiselton-Dyer 1883) is reported to be confined to the Seshachalam Hills (Tirupati-Kadapa Hills) of Andhra Pradesh State, India. Its conservation status has been variously assessed as Vulnerable (Nayar & Sastry 1987), Endangered (Rao et al. 2003) and Critically Endangered (Jadhav et al. 2001; Hill et al. 2003). Based on direct field observation the threat status of the species has been evaluated as 'Endangered' through grid sampling (Rao et al. 2010) and this work has been reviewed and adopted by the IUCN Red List (IUCN 2014). It is the only Indian cycad and the only species of *Cycas* that is listed on Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I (Inskipp & Gillett 2005) and this categorization has also been supported by Rao et al. (2010).

Rao et al. (2010) assessed its conservation status as 'Endangered' by laying 15 transects in the Seshachalam Hills. In the present study, the population was monitored in those transects and further sampling was carried out in 11 new transects, four in the Seshachalam Hills and seven in the Velikonda Hills. The latter is a new area discovered with a new subpopulation of the species through ecological niche modelling. Based on earlier

and current datasets, species distribution is updated, current population size is estimated and conservation status is evaluated.

## MATERIALS AND METHODS

The study area is confined to the Seshachalam and Velikonda hills of Andhra Pradesh (Image 1). From 2011 to 2014, the *Cycas beddomei* population was monitored in 15 transects of 1kmx5m size and inventoried the species in four new transects of size 500x5 m in Seshachalam hills all laid in 13 grids each of 40km<sup>2</sup> size. In addition, based on the findings through ecological niche modelling the population was assessed in the Velikonda Hills bordering Nellore and Kadapa districts. Due to sparse and scattered distribution of the species in the Velikonda hills, the area is sampled through seven transects of 500x5 m size each laid in seven grids of 40km<sup>2</sup> size. The number of mature individuals (>2cm stem height) were enumerated and the area of occupancy was estimated in individual grids. The number of mature individuals was extrapolated taking into consideration the topographic limitations of the species occurrence based on field observations. All the transect sites are geo-coded. In both the areas, the numbers of male and female plants were counted transect-wise based on Whitelock's (2002) observations that male plants tend to form clumps and the females grow as single stems.

The area of occupancy was calculated in 20 grids; 13 in the Seshachalam Hills and seven in the Velikonda Hills,

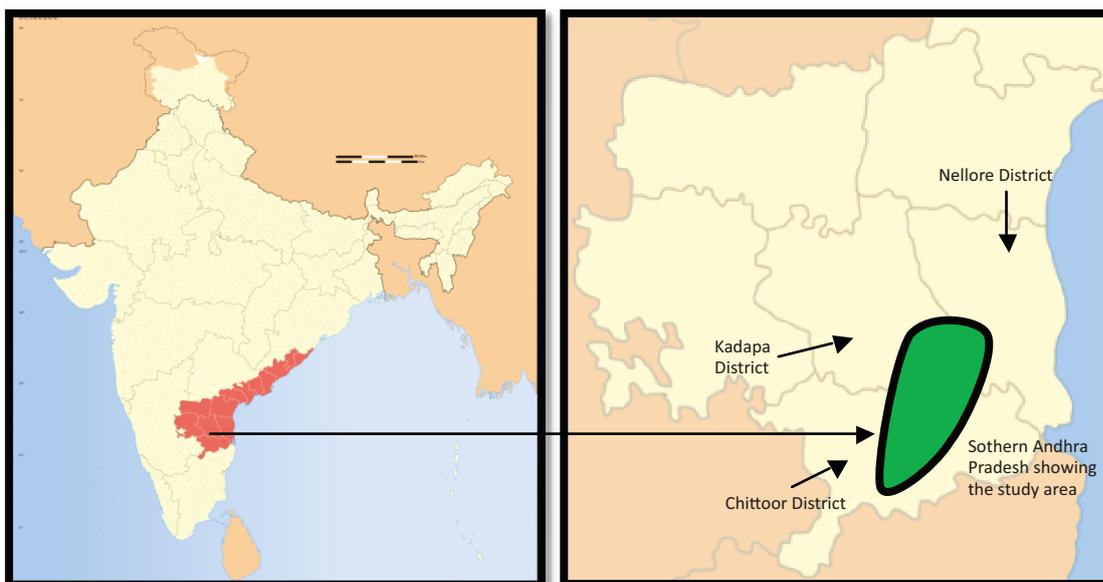


Image 1. Study area

by combining the observations from the present study as well as the earlier one. The locations and subpopulations were revised for the species throughout its terrain following IUCN guidelines (IUCN 2001; IUCN Standards and Petitions Subcommittee 2014). Accordingly, subpopulations are considered as geographically or otherwise distinct groups in the population between which there is little demographic exchange. Taking into consideration the topographic limitations of species occurrence in its native habitat, the area of occupancy was calculated and extrapolation of the number of mature individuals was done on the basis of the grids in the study area. The whole geographic range of the species is mapped based on field observations.

The conservation status of *Cycas beddomei* has been reassessed based on the observations from the newly sampled transects. For determining the three threatened categories, namely Critically Endangered, Endangered and Vulnerable, five criteria are used in the IUCN Species Survival Commission guidelines (IUCN 2001). However, for *C. beddomei*, only criteria B, C and D are applied as A and E criteria require long-term observations. For the purpose of measuring the Extent of Occurrence (EOO) and the Area of Occupancy (AOO), satellite imagery of IRS-1C has been stratified with 40km<sup>2</sup> grids. The AOO is defined as the area within its 'EOO' which is occupied by the taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its 'EOO', which may contain unsuitable or unoccupied habitats (IUCN Standards and Petitions Subcommittee 2014).

## RESULTS AND DISCUSSION

### Nomenclature

*Cycas beddomei* Dyer, Trans. Linn. Soc. London, Bot. 2(5): 85, pl. 17. 1883. Lindstrom & Hill in Telopea 11(4): 470. 2007. *Cycas circinalis* var. *beddomei* (Dyer) J. Schust., Pflanzenr. IV, 1: 67.1932. *Cycas pluma* W. Bull, Retail List New Beautiful Rare Pl. 142: 478. 1877 (Image 2).

### Botanical description

Stems arborescent, appear like a small palm with a distinct trunk of up to 1.5m high. The stem is covered with the remnants of leaf bases. Leaves up to 30 in number form a crown at top of the stem, 70–120 cm long. Petioles up to 20cm long, with minute spines. Leaflets narrow, linear, 12–18 × 2–0.4 cm, with revolute margins. The plants are dioecious. Male cones oblong-

ovoid, up to 32×16 cm, orange, with a short peduncle; microsporophyll with an apical spine up to 3cm long. Megasporophylls grow up to 4×2 cm and with pectinate margins. Ovules 2–4, occasionally 6–8, inserted above the middle of the stalk, up to 4cm across. Seeds globose-ovoid, with fibrous sarcotesta, up to 5×5 cm, green, turning yellow on maturity.

### Ecology

Found on dry, open hill slopes, in woodland or grass dominated forested areas at an altitude between 500–1165 m. The species is mostly restricted to the top slopes and predominantly in black soils. Common associate species are: *Phoenix humilis*, *Terminalia pallida*, *Syzygium alternifolium*, *Pimpinella tirupatiensis*, *Curculigo orchioides*, *Cymbopogon* spp. and *Dechaschistia* spp.

Reproductive period: April–August.

### Common name

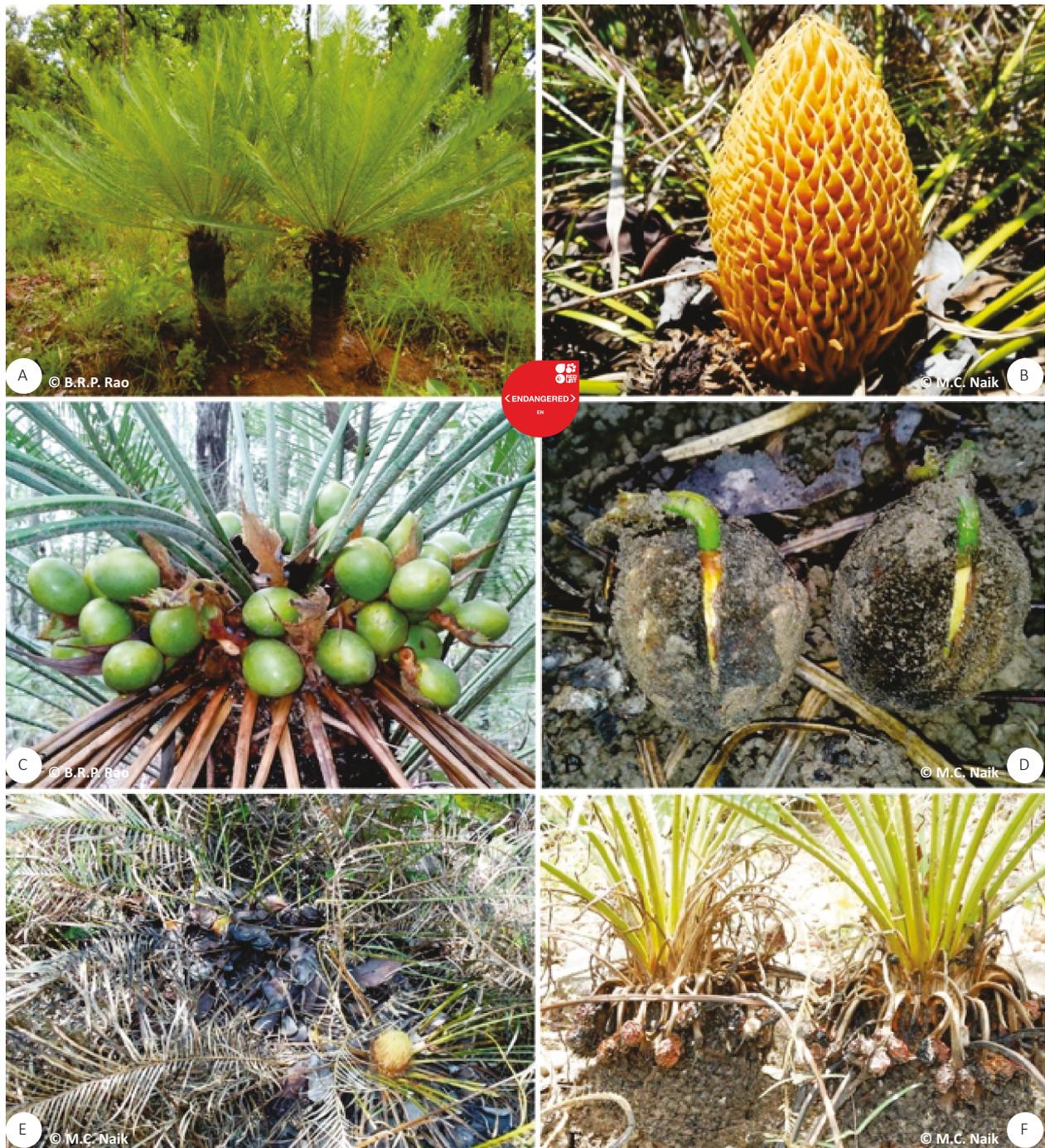
Beddome's Cycas (English); Peritha, Madanakamakshi and Kondaeetha (Telugu).

### Uses

The seeds are harvested for preparing flour by the local people. The, male cone extracts are used to prepare a health tonic by the local Yanadi tribes and rural communities. The pith is harvested often for use in abortion.

### Sub-populations and locations of the species

Totally, 3962 mature individuals of *Cycas beddomei* were enumerated in 26 transects laid in 20 grids (Table 1). Of these, 2834 individuals were recorded in the Seshachalam hills and 1128 in the Velikonda Hills. In both the areas, the male: female ratio was about 1:3. Since all of the individuals in the Seshachalam Hills were inferred to have some minimum demographic exchange throughout the terrain, these were considered together as 'one sub-population' since fire is only threat factor affecting the population all are considered under one location. In the Velikonda Hills, all the individuals are considered as one sub-population distributed in one location as the whole sub-population is affected by pest. This discovery of the species in the Velikonda Hills is significant as till date, no published data is available on the species occurrence in the area. Although there is no overall estimate of decline, the population is considered to be experiencing decline because of habitat modification and continuing threats from forest fires. Hence with the current field observations in the native habitat of the species, we could demarcate two



**Image 2.** *Cycas beddomei*: A - Habit; B - Male plant; C - Female plant; D - Germinating seeds; E - Diseased plants; F - Fire affected plants showing deformed fruits.

subpopulations separated by about 40km; one entirely falling in the Seshachalam Hills and the other in the Velikonda Hills with a total of eight locations.

#### **Distribution pattern of the species**

The species is now recorded from the Seshachalam and the Velikonda Hills covering Chittoor, Kadapa and

Nellore districts. The species has patchy distribution within the grids and substantial areas in the individual grids (about 80% in many cases) did not have plants. Although we located isolated trees at 500–600 m altitude, most of the population lies at an altitudinal range of 600–1150 m. We found in the past four years the AOO is reduced by 5–10 % in different locations and

Table 1. Sampled inventory of *Cycas beddomei* population

Grid No.	Transect No.	Transect size (in m)	Altitude (above MSL)	No. of individuals (male+female)	Estimated AOO in km <sup>2</sup> (extrapolated individuals)
<b>A. Seshachalam Hills sub-population</b>					
1	1	1000×5	800	141 (42+99)	2.0 (40,533)
	2	1000×5	790	132 (29+103)	
	3	1000×5	750	31 (7+24)	
2	4	1000×5	860	120 (35+85)	0.9 (21,600)
3	5	1000×5	650	103 (24+79)	2.4 (34,920)
	6	1000×5	792	55 (17+38)	
4	7	1000×5	980	143 (36+107)	1.2 (34,320)
5	8	1000×5	1010	170 (45+125)	1.1 (37,400)
6	9	1000×5	960	190 (48+142)	1.2 (40,560)
	10	1000×5	950	148 (30+118)	
7	11	1000×5	920	161 (40+121)	1.0 (32,000)
8	12	1000×5	850	76 (21+55)	1.9 (28,880)
9	13	1000×5	1150	137(34+103)	1.2 (32,880)
10	14	1000×5	820	124 (32+92)	1.2 (29,760)
11	15	1000×5	1108	194 (50+144)	0.8 (16,586)
	16	500×5	872	58 (16+42)	
12	17	500×5	838	142 (37+105)	0.6 (14,340)
	18	500×5	814	97 (23+74)	
13	19	500×5	832	163 (46+117)	0.5 (15,750)
ubtotal		8.5 ha	-	2834 (734+2100)	16.2 (3,79,529)
<b>B. Velikonda Hills sub-population</b>					
14	20	500×5	694	102(24+78)	0.05 (1020)
15	21	500×5	731	78(21+57)	0.05 (780)
16	22	500×5	742	202(46+156)	0.05 (2020)
17	23	500×5	680	250(72+178)	0.05 (2500)
18	24	500×5	809	83(18+65)	0.05 (830)
19	25	500×5	670	193(42+151)	0.03 (1158)
20	26	500×5	684	220(64+156)	0.04 (1760)
Subtotal		1.75 ha	-	1128 (287+841)	0.32 (11,088)
Total		10.25 ha	-	3962 (2834+1128)	16.52 (3,90,617)

the number of mature individuals has come down in some grids (ranging from 100 to 300) which is attributed to intensive and recurrent forest fires.

### Population size

The species population is estimated to comprise over 3.9 lakh individuals (Table 1); 97% of it is in the Seshachalam Hills.

### Threats to the species

*Cycas beddomei* is experiencing population decline because of habitat modification and continuing threats

especially from forest fires. These fires have become more prominent and recurrent in the past few years. The natural threats are in the form of hemipteran scale *Saissetia coffeae* and lepidopteran butterfly *Chilades pandava* in its natural habitat; persistent occurrence of the former and massive infestation by the latter may prove fatal in the future (Srivastava 2011). Harvesting of male cones for medicinal purpose; uprooting plants for ornamental purpose; occasional collection of individuals for pith extraction for flour making are other major threats.

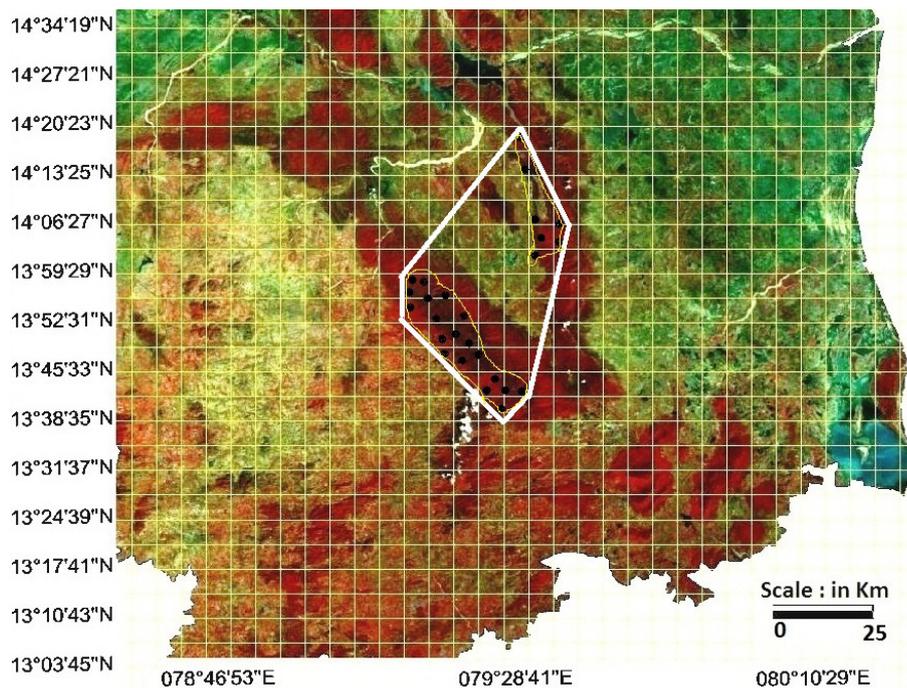


Image 3. *Cycas beddomei* - distribution sites and EOO/AOO map

#### Evaluation of current conservation status

The whole population of the species is considered under '2 locations' comprising two subpopulations. The Extent of Occurrence (EOO) of the species is calculated as 1713km<sup>2</sup> (Image 3). Taking the topographic limitations throughout its geographic range, the Area of Occupancy (AOO) was measured as 16.52km<sup>2</sup> (1652 ha) (Table 1; Image 3) and the number of mature individuals was extrapolated to 3.90 lakhs.

**Criterion B: B1:** The EOO of the species is estimated at 1713km<sup>2</sup> and hence categorized as 'Endangered'. Of the three conditions to be fulfilled under B1, the species is found to qualify two: (a) no more than five locations and (b) Continuing decline observed under the sub criteria: (ii) area of occupancy (iii) area, extent and or quality of habitat and (v) no. of mature individuals. **B2:** The AOO is 16.52km<sup>2</sup> and since this estimate is less than 500km<sup>2</sup>, the species is qualified under 'Endangered' category. The species also fulfils two of the three conditions: (a) no more than five locations and (b) continuing decline observed under the sub criteria: (ii) area of occupancy (iii) area, extent and or quality of habitat and (v) no. of mature individuals.

**Criterion C and D:** Since the estimated population comprise more than 10,000 individuals it is not qualified for any of the three threatened categories under these criteria.

**Final assessment:** EN B1ab(ii,iii,v)+B2ab(ii,iii,v)

#### CONCLUSIONS

The global distribution of the species is redefined as 'Endemic to the Seshachalam and the Velikonda hills of the southern Eastern Ghats of Andhra Pradesh, India' due to the discovery of a new sub-population in the Velikonda Hills. Despite its extended geographic distribution, its 'Endangered' status has been retained following the IUCN Red List guidelines. Owing to its restricted distribution and slow growth its current status of Appendix I of CITES is also to be retained.

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**RED LIST ASSESSMENT: *CYCAS BEDDOMEI***

Kingdom: Plantae  
 Phylum: Tracheophyta  
 Class: Cycadopsida  
 Order: Cycadales  
 Family: Cycadaceae  
 Genus: *Cycas*  
 Species: *beddomei*  
 Authority: Thiselton-Dyer, 1883.

**Common name:** Beddome's Cycas (English); Peritha, Madanakamakshi and Kondaetha (Telugu).

**Taxonomic notes:** The species was described first by Thiselton Dyer (1883) with distribution in Cuddapah Hills, although its presence was first observed by Beddome (1869) who recorded it as *Cycas revoluta*. Type specimen is from Cuddapah hills: H.H. Yarde s.n., Aug. 1882 (syn. K, 3 sheets; isosyn. BM, 1). The species is considered valid and *Cycas beddomei* is an accepted name as per version 1.1 of The Plant List (2013).

**ASSESSMENT INFORMATION**

**Red List Category and Criteria (Version 3.1):** Endangered B1ab(ii,iii,v)+B2ab(ii,iii,v)

**Justification:** The whole population of the species is considered under two locations comprising two sub-populations. The extent of occurrence is calculated as 1,713km<sup>2</sup>; area of occupancy, 16.52km<sup>2</sup> and the number of mature individuals is extrapolated to 3.90 lakhs. Major threats such as fire, pests and harvest for medicinal and ornamental purposes keep this species as Endangered due to the continuing decline observed on the area/quality of habitat and number of mature individuals.

**GEOGRAPHIC RANGE / DISTRIBUTION INFORMATION**

**Range description:** The species is endemic to Seshachalam and Velikonda hills in southern Andhra Pradesh, India and is found at an altitudinal range of 500–1,165 m.

**Countries of occurrence:** Native to India (Andhra Pradesh State).

**Extent of Occurrence (EOO):** EOO is estimated at 1713km<sup>2</sup> with distribution in Seshachalam Hills and Velikonda Hills.

**Area of Occupancy (AOO):** AOO is estimated to be 16.52km<sup>2</sup>; 16.2km<sup>2</sup> in Seshachalam Hills and 0.32km<sup>2</sup> in Velikonda Hills.

**Number of locations:** The species is currently found in two locations.

**Range map:** See Image 3.

**POPULATION INFORMATION**

**Population:** The species is estimated to have about 3.90 lakh mature individuals, of which 3.79 are estimated to be found in the Seshachalam Hills and the remaining in the Velikonda Hills.

**Population trend:** The population is declining. Over the last four years about 5–10 % population has declined across its terrain due to various threats primarily due to fire in the Seshachalam Hills and to diseases in the Velikonda Hills.

**HABITAT AND ECOLOGICAL INFORMATION**

**Habitat and ecology:** The species is a small palm-like plant growing to a maximum 1.6 m. Found on dry, open hill slopes, in woodland or grass dominated forested areas at an altitude between 500–1165 m. The species is mostly restricted to top slopes and predominantly black soils. The common associate species are: *Phoenix humilis*, *Terminalia pallida*, *Syzygium alternifolium*, *Pimpinella tirupatiensis*, *Curculigo orchioides*, *Cymbopogon* spp. and *Dechaschistia* spp. Vegetative growth is profuse during the rainy season from July to August with cone setting and fruit formation from September onwards until November. Key threats to the species observed in the study area are infestation of caterpillars on young leaves and bugs causing deformation of plant parts; sometimes it retards plant growth and ultimately leads to plant death.

**System:** Small arborescent plant.

**INFORMATION ON THREATS**

**Threats:** The main threats to species population are: forest fires in Seshachalam Hills, and pest attack in Velikonda Hills. The natural threats are in the form of hemipteran scale *Saissetia coffeae* and lepidopteran butterfly *Chilades pandava* in its natural habitat.

**Additional threats:** Harvesting of male cones for medicinal purpose; uprooting plants for ornamental purpose; occasional collection of individuals for pith extraction for flour making are other major threats.

**USE AND TRADE INFORMATION**

**Use:** The seeds are harvested for preparing flour by the local people. The male cone extracts are used to prepare a health tonic by the local Yanadi tribes and rural communities. The pith is harvested often for use in abortion. The whole plant is harvested for ornamental purposes.

**Livelihoods and sustenance:** There are no recognised livelihood dependence or sustenance practices on this species.

**Trend in off take from the wild:** Not known.

**Trend in off take from cultivation:** No reports so far.

**INFORMATION ON CONSERVATION ACTIONS**

**Conservation actions:** The species distribution range falls within Seshachalam Biosphere Reserve which encompasses Sri Venkateswara National Park, Sri Venkateswara Wildlife Sanctuary and Sri Penusila Narasimhaswamy Wildlife Sanctuary. Since the species is listed under CITES no form of international trade is recorded. Forest department intensive vigilance in view of illegal transport of Red Sanders is imparting further protection to the species. Forest department is propagating the species through seeds.

**Research in place:** As part of the project activity, we are propagating saplings from seeds and plan to augment the existing population in the native area.

**Research needed:** Reproductive studies to understand infrequent seed setting needed. Pest infection and control is another area of needed research. Standardised propagation methods for early germination is a key area for research.

**Monitoring in place:** Currently under DBT project we are monitoring the species population and developing an ecological niche model for the species.

**Education in place:** Informal, sporadic and opportunistic education to villagers by the forest department and our research team.

**Education needed:** Sustained awareness programmes about the importance of the cycad, its endemism and significance as a threatened and flagship species is needed.

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