



# Ecology and conservation of threatened plants in Tapkeshwari Hill ranges in the Kachchh Island, Gujarat, India

P.N. Joshi<sup>1</sup>, Ekta B. Joshi<sup>2</sup> & B.K. Jain<sup>3</sup>

<sup>1</sup> Sahjeevan, 175-Jalaram Society, Vijay Nagar, Bhuj, Kachchh, Gujarat 370001, India

<sup>2</sup> Matruchhaya Kanya Vidhyalay, Matruchhaya Road, Bhuj, Kachchh, Gujarat 370001, India

<sup>3</sup> M.G. Science Institute, Gujarat University, Ahmedabad, Gujarat, India

Email: joshi\_pn@yahoo.com (corresponding author), noopur\_pj@yahoo.co.in, bkjain\_mgsc@yahoo.com

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**Abstract:** The survey was conducted in Tapkeshwari Hill Range (THR) areas, wherever threatened plant species were said to exist, based on secondary information in literature. Thirteen plant species categorized as 'Threatened' by the World Conservation Monitoring centre (WCMC 1994) and also listed under various threat categories in the Red Data Book of Indian Plants (Nayar & Sastry 1988) were surveyed in the THR. All the RET plants reported from the study area occupied eight major habitat types. Thorn mixed forests harbored the highest number of individuals (560) of all RET plants, followed by open scrubs (345 individuals), *Acacia senegal* forests (328) and thorn mixed scrubs (293). Field observations showed that except *Helichrysum cutchicum*, all the other RET plant species were reported with very low seedlings and regeneration ratio. This paper discusses the status, distribution and threats faced and the conservation implications at border regions of some of the threatened plants of the arid Kachchh district.

**Keywords:** Conservation, distribution, ecology, endangered, rare, threatened, threats.

## INTRODUCTION

Zietsman et al. (2008) stated that small and isolated populations often suffer from disrupted biological interactions. Nearly 1500 species of higher plants in India are listed as threatened, most of which are angiosperms (Daniels & Jayanthi 1996). These plants have their own ecological role in the ecosystem and therefore, the conservation status of lesser known plant species and isolated populations need to be assessed both within individual populations and at the metapopulation level (Shaw & Burns 1997). There is reported work in the past in Tapkeshwar Hill Range (THR) on threatened species, especially their ecological requirements. This study is intended to highlight the status and distribution of the species in the study area, the ecological characteristics necessary for their survival, and the threats faced by some of the species designated by following the criteria devised by WCMC and IUCN (Nayar & Sastry 1988; WCMC 1994; Bhandari et al. 1996; GES et al. 2002).

## MATERIALS AND METHODS

The study area (Tapkeshwari Hill Range - THR) of more than 140km<sup>2</sup> (14,400ha) covering nine villages under two taluks, i.e. Bhuj and Mundra was surveyed (Image 1). THR is the largest unexplored hilly tract in the district. It is close to Bhuj City, the district headquarters (7km) and provides a high diversity of floral species in various vegetation types or



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habitats like *Euphorbia* scrubs, *Prosopis* scrubs, thorn mixed scrubs, open scrubs, thorn mixed forests with *Acacia senegal*, *A. nilotica* and *Salvadora* mixed (Image 2). Considering the high floral diversity and unique vegetation assemblage of this range, it has been suggested that, this tract and adjoining sites may be declared as Ecologically Sensitive Areas (ESA) (Joshi 2002).

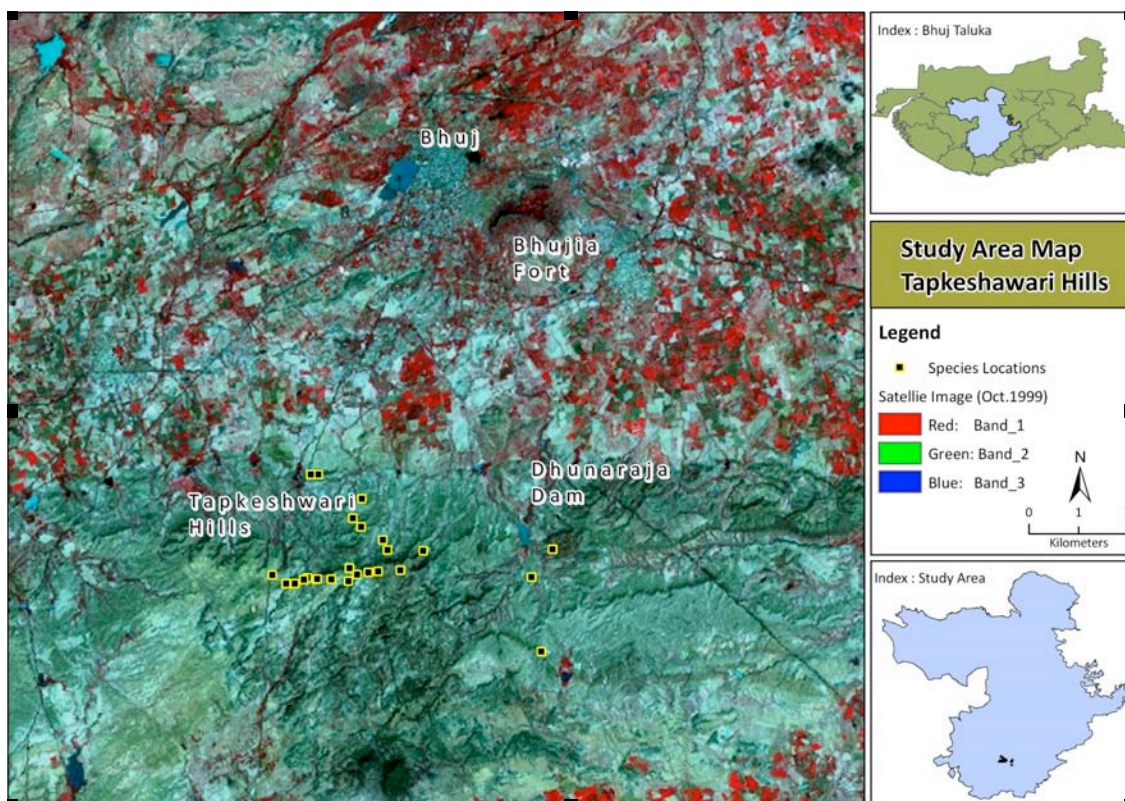
The selected hill ranges experience extremes of weather condition and have three seasons, consisting of winter, summer and monsoon—winter (November to February; minimum averaging 10°C), summer (March to June; maximum 38.7°C) and monsoon (July to September; average 394.7mm in 2007-2009 and for 16.2 days).

The survey was conducted in the study areas wherever rare, endangered and threatened (RET) plant taxa were said to exist, based on information in the literature (Nayar & Sastry 1988; WCMC 1994; GES et al. 2002). In addition, other adjoining areas, which had similar habitat types where the plants were seen during the survey, were also searched. A combination of belt transects with centred quadrates method were used for sampling. Belt transects of 5m width and length



**Image 2. Overall distribution of RET plants in various habitats**

extending to the entire width of the patch were laid. Within this belt, species specific search was carried out and once a target species was located, a species-centred circular plot of 5m radius in the case of shrubs and 1 to 2 m radius in the case of herbs were laid. In case of abundance of plants, belt transects radiating from the edge of the aquatic body in eight directions were laid to assess the number, and the extent of their spread from the main microhabitat was used to record all other parameters as above.



**Image 1. The location of study area**

## RESULTS

### IUCN- RET Plants Reports

Thirteen plant species categorized as threatened by the World Conservation Monitoring Centre (WCMC 1994) and also listed under various threat categories in the Red Data Book of Indian Plants (Nayar & Sastry 1988) were surveyed in the THR. In many rare species classifications, including the Red Book listings of the IUCN, two types of rarity—natural and induced—are not always clearly distinguished. Some species that are naturally rare are also ranked as threatened with extinction. While naturally rare species can be more vulnerable to extinction than common ones, rarity in itself is not synonymous with extinction threat. Understanding the difference between natural and induced rarity is important for focusing conservation efforts.

Out of the 19 RET plants recorded so far from Kachchh (Shah 1978; Nayar & Sastry 1988; Raole 1993; WCMC 1994; GES et al. 2002), 13 taxa were located in the study area: six herbs, four undershrubs, two shrubs and one climber. Among these, *Dipcadi erythraeum*, *Dactyliandra welwitschii*, *Indigofera caerulea* var. *monosperma* and *Pavonia ceratocarpa* had very low numbers, i.e. 9, 13, 16 and 19 individuals, respectively, and had highly restricted distribution in THR. *Commiphora wightii*, *Ipomoea kotschyana*, *Helichrysum cutchicum* and *Campylanthus ramosissimus* showed wider distribution and had 612, 440, 245 and 235 individuals, respectively (Table 1). The details on abundance, habitats and threats of each taxon with their present status mentioned by different authorities are given in Table 1.

### Distribution and age structure status

Overall distribution status of RET taxa in the study area: All the RET plants reported from the study area occupied eight major habitat types, of which thorn mixed scrub, open scrub and *Acacia senegal* forest harbored the highest number (10 in each) of taxa. The second highest number of taxa (9) was recorded from thorn mixed forest and *Euphorbia* scrub and so on (Table 2). Interestingly, thorns mixed forest harbored the highest number of individuals (560) of all RET plants, followed by open scrub (345 individuals), *Acacia senegal* forest (328), thorn mixed scrub (293) and so on (Fig. 1).

*Campylanthus ramosissimus*, *Ipomoea kotschyana* and *Pavonia ceratocarpa* were restricted to a single favorable habitat, viz., open scrub, thorn mixed forest and *Euphorbia* scrub respectively. *Commiphora wightii*, *Convolvulus stocksii*, *Ephedra foliata* and *Helichrysum cutchicum* also showed more affinity to the thorn mixed scrub (31.37%), thorn mixed forest (44.88%), thorn mixed forest (45.45%) and *Acacia senegal* forest (30.20%) respectively (Table 2).

Figure 1 shows there is no co-relation between the total number of plots (laid down for sampling) and individual count of RET plants in each habitat in the study area.

Age structure status of RET plants in THR: In this title detailed study on the RET plant species reproduction (with different age classes), regeneration, recruitment and adult plants were documented. However, a total of 13 species have been reported as threatened species in the study area. Only four species like *Campylanthus ramosissimus*, *Citrullus colocynthis*, *Commiphora wightii* and *Helichrysum cutchicum* were recorded under various reproduction classes in the sample area (Table 3).

Quantification of the reproductive stage of annual herbaceous plants is difficult when compared to bushy perennials because of their smaller size and very short life spans. It is further complicated if it has restricted distribution and low abundance. Within the sample area, field observation showed that except *Helichrysum cutchicum*, all other RET plant species are reported with very low seedlings and regeneration ratio (Table 3) when compared with the adult plants. In addition, low abundance of some RET plant species could be inherent and for others it may be failure of regeneration.

### Threats faced

The details of the different kinds of threats faced by the RET plants species were also reported with respect to different stresses and the total number of plants affected along with information on each threat. Species-wise natural and anthropogenic threats faced and the individuals affected are given in Table 4. Natural and anthropogenic disturbances can have dramatic consequences for population growth, particularly for small populations of threatened plants (Coates et al. 2006; Tian et al. 2007); a plant species might be naturally rare because its habitat is restricted

**Table 1. Ecology and distribution of RET plants in various habitats**

Species	Family	No	Preferable habitat	Threats	Remarks	Status	Source
<i>Campylanthus ramosissimus</i> Wt.	Scrophulariaceae	235	Open scrub	Habitat loss	Restricted to certain sandstone formations and lime stone hills	Rare Endangered	Nayar & Sastry 1988 WCMC 1994 CREB-GUIDE 2002
<i>Citrullus colocynthis</i> (L.) Soland.	Cucurbitaceae	65	Thorn mixed forest	Habitat loss	Recorded on sand dunes and sandy grounds	Rare Common	Bhandari 1990 CREB-GUIDE 2002
<i>Commiphora wightii</i> (Arnott) Bhandari	Burseraceae	612	Thorn mixed scrub	Over exploitation	Dominant on rocky hillocks and hard gravelly soils	Threatened Not Evaluated Indeterminate Common	Rao 1981 IUCN WCMC 1994 CREB-GUIDE 2002
<i>Convolvulus stocksii</i> Boiss.	Convolvulaceae	127	Thorn mixed forest	Over grazing	Mostly restricted to loamy and gravelly soils with moderate soil depth	Threatened Rare Indeterminate Common	Rao 1981 Sabnis & Rao 1983 WCMC 1994 CREB-GUIDE 2002
<i>Dactyliandra welwitschii</i> Hook.f.	Cucurbitaceae	13	Thorn mixed forest	-	Mostly associated with <i>Euphorbia</i> cactus	Common Data Deficient	Bhandari 1990 CREB-GUIDE 2002
<i>Dipcadi erythraeum</i> Webb. & Berth.	Liliaceae	9	Open scrub	Erosion	Site specific and require moist soil substratum	Rare Indeterminate Common	Rao 1981 WCMC 1994 CREB-GUIDE 2002
* <i>Ephedra foliata</i> Boiss. & Kot.ex Boiss	Ephedraceae	55	Thorn mixed forest	Cutting associated plants	Mainly found on sandy, gravelly or even rocky areas	Rare Not Evaluated Vulnerable	Rao 1981 IUCN CREB-GUIDE 2002
<i>Helichrysum cutchicum</i> (C.B. Cl.) Rolla Rao et Des.	Asteraceae	245	<i>Acacia senegal</i> forest	Habitat degradation	Prefer undulating terrain and sand stone with sparse grasses cover	Rare Rare & Endemic Lower Rick	Nayar & Sastry 1988 WCMC 1994 Sabnis & Rao 1983 CREB-GUIDE 2002
<i>Indigofera caerulea</i> Roxb. var. <i>monosperma</i> (Sant.) Sant.	Fabaceae	16	Open scrub	Over grazing	Found on pebbly and gravelly substrate with sandy substratum	Rare Rare and Endemic Vulnerable	Nayar & Sastry 1988 WCMC 1994 Rao,K.S.S 1981 CREB-GUIDE 2002
<i>Ipomoea kotschyana</i> Hoc. ex Choisy	Convolvulaceae	440	Thorn mixed forest	Sand mining	Sandy substratum and site specific	Common Not Evaluated Indeterminate Common	Rao 1981 - WCMC 1994 CREB-GUIDE 2002
<i>Pavonia ceratocarpa</i> Mast.	Malvaceae	19	<i>Euphorbia</i> scrub	-	Loamy soil with moderate soil depth	Rare Indeterminate Endangered	Rao 1981 WCMC 1994 CREB-GUIDE 2002
<i>Sida tiagii</i> Bhandari	Malvaceae	37	<i>Acacia senegal</i> forest	Habitat loss	Found mainly on open sandy ground with sparse vegetation cover	Common Indeterminate Common	CREB-GUIDE 2002 WCMC 1994 CREB-GUIDE 2002
<i>Tribulus rajasthanensis</i> Bhandari et Sharma	Zygophyllaceae	43	<i>Euphorbia</i> scrub	Habitat degradation	Rocky plateau and sandstone hills	Rare Indeterminate Endangered	IUCN WCMC 1994 CREB-GUIDE 2002

\* - Wild gymnosperm species

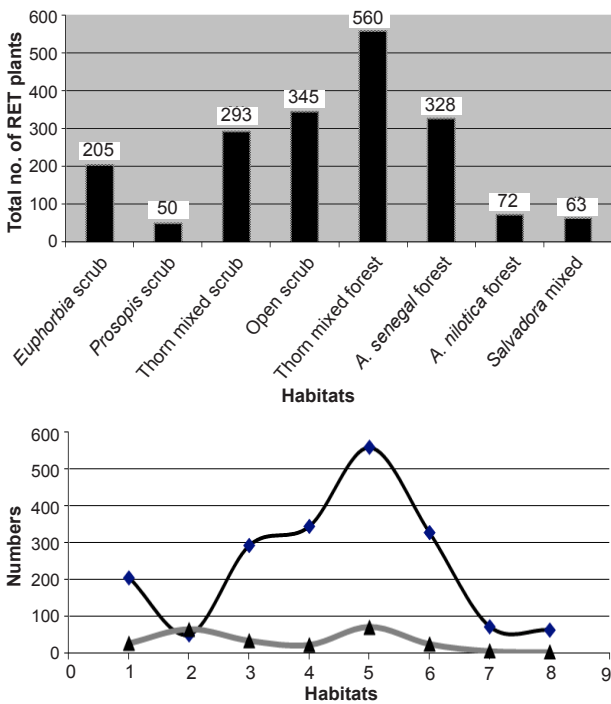
(de Lange & Norton 2004). Many species at risk of extinction in the United States are declining because of habitat loss and degradation (Hodges & Elder 2008). Selective cutting causes microclimatic changes and decreases the amount of old and dead trees, which may threaten the persistence of many threatened species (Pykala 2007).

In case of *Campylanthus ramosissimus*, the common and major threat faced was browsing by cattle, goats and sheep; habitat degradation and some individuals

by termites. For *Citrullus colocynthis*, soil collection in dry riverine/nallahs and naturally dry conditions are prominent threats. *Commiphora wightii* is threatened due to its illegal exploitation by pharmaceutical and perfumery industries (Sabnis & Rao 1983). It is also used as folk medicine and is one of the highly commercially exploited species. Poor techniques associated with tapping of gum resin have lead to its total destruction in its natural habitat (Cooke 1958; Kumar & Bhandari 1994). During this study it was

**Table 2. Distribution of rare, endangered and threatened plants in various habitats in THR**

Ret plants	Total plots	RET plants in various macro habitat															Total species		
		Euphorbia scrub	Rel%	Prosopis scrub	Rel%	Thorn mixed scrub	Rel%	Open scrub	Rel%	Thorn mixed forest	Rel%	A. senegal forest	Rel%	A. nilotica forest	Rel%	Salvadora mixed		Rel%	
<i>Campylanthus ramosissimus</i>	63	26.81	13	5.53	27	11.49	132	56.17	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	235
<i>Citrullus colocynthis</i>	0	0.00	3	4.62	11	16.92	3	4.62	17	26.15	16	24.62	3	4.62	12.00	18.46			65
<i>Commiphora wightii</i>	59	9.64	7	1.14	192	31.37	123	20.10	77	12.58	112	18.30	34	5.56	8.00	1.31			612
<i>Convolvulus stocksii</i>	8	6.30	0	0.00	18	14.17	17	13.39	57	44.88	27	21.26	0	0.00	0.00	0.00			127
<i>Dactyliandra welwitschii</i>	0	0.00	0	0.00	4	30.77	0	0.00	6	46.15	0	0.00	0	0.00	3.00	23.08			13
<i>Dipcadi erythraeum</i>	4	44.44	0	0.00	0	0.00	5	55.56	0	0.00	0	0.00	0	0.00	0.00	0.00			9
<i>Ephedra foliata</i>	4	7.27	0	0.00	7	12.73	4	7.27	25	45.45	13	23.64	2	3.64	0.00	0.00			55
<i>Helichrysum cutchicum</i>	34	13.88	15	6.12	22	8.98	45	18.37	32	13.06	74	30.20	23	9.39	0.00	0.00			245
<i>Indigofera caerulea var. monosperma</i>	0	0.00	0	0.00	3	18.75	6	37.50	6	37.50	1	6.25	0	0.00	0.00	0.00			16
<i>Ipomoea kotschyana</i>	0	0.00	0	0.00	0	0.00	0	0.00	335	76.14	65	14.77	0	0.00	40.00	9.09			440
<i>Pavonia ceratocarpa</i>	13	68.42	2	10.53	0	0.00	0	0.00	0	0.00	4	21.05	0	0.00	0.00	0.00			19
<i>Sida tiagii</i>	7	18.92	0	0.00	4	10.81	5	13.51	5	13.51	8	21.62	8	21.62	0.00	0.00			37
<i>Tribulus rajasthanensis</i>	13	30.23	10	23.26	5	11.63	5	11.63	0	0.00	8	18.60	2	4.65	0.00	0.00			43
<b>Overall total ret plants</b>	<b>205</b>	<b>10.70</b>	<b>50</b>	<b>2.61</b>	<b>293</b>	<b>15.29</b>	<b>345</b>	<b>18.01</b>	<b>560</b>	<b>29.23</b>	<b>328</b>	<b>17.12</b>	<b>72</b>	<b>3.76</b>	<b>63</b>	<b>3.29</b>			<b>1916</b>
<b>Total plots in each habitat</b>	<b>27</b>	<b>10.6</b>	<b>65</b>	<b>25.6</b>	<b>34</b>	<b>13.4</b>	<b>23</b>	<b>9.07</b>	<b>71</b>	<b>28</b>	<b>25</b>	<b>9.84</b>	<b>6</b>	<b>2.36</b>	<b>3</b>	<b>1.18</b>			<b>254</b>



**Figure 1. Co-relation between total number of plots and individuals of RET plants in various habitats**

noted that it was facing four types of anthropogenic and two types of natural threats (Table 4).

*Dipcadi erythraeum* and *Ephedra foliata* were threatened by habitat degradation and soil erosion in the study area. No threats were observed on *Dactyliandra welwitschii*, *Indigofera caerulea var. monosperma*, *Pavonia ceratocarpa* and *Sida tiagii*, during the present investigation, but grazing in the area of occurrence of the species could affect these species by trampling and top soil removal by cattle. In-depth studies are required to identify the threats faced by the species. In the case of *Ipomoea kotschyana* and *Tribulus rajasthanensis*, no specific threats were noted, but habitat degradation was observed at a few sites.

The subjective rating of threats based on the field observation showed that except *Convolvulus stocksii*, all other RET plant taxa faced major threat in the form of habitat degradation (anthropogenic stress or threat) (Table 4; Image 3) due to excessive livestock grazing.

**Table 3. Regeneration status of rare, endangered and threatened (RET) plants**

Area surveyed (In km.)	Sampled units (In ha)	Total adult plants (>60cm height)	Density/ ha	Total no. of plants		
				Seedlings (<10cm)	Regeneration (>10–25 cm)	Recruitment (>25–60 cm)
<b><i>Campylanthus ramosissimus</i></b>						
5.00	1.57	32	20.36	12 (37.50%)	7 (21.87%)	2 (6.25%)
<b><i>Citrullus colocynthis</i></b>						
2.20	0.69	9	13.02	3 (33.33%)	-	-
<b><i>Commiphora wightii</i></b>						
12.00	3.77	286	75.84	34 (11.88%)	19 (6.64%)	13 (4.55%)
<b><i>Helichrysum cutchicum</i></b>						
5.00	1.57	149	94.82	65 (43.63%)	38 (25.51%)	30 (2.14%)

## DISCUSSION AND CONCLUSIONS

The phytosociological analysis with ecological information of RET plants revealed that the *Campylanthus ramosissimus*, *Commiphora wightii*, *Helichrysum cutchicum* and *Ipomoea kotschyana* have abundant populations in the THR. These species require site-specific conservation strategies with

the help of the forest department for their long term survival in the study area.

Among the assessed 13 species, five species are reported to be medicinally important in Kachchh (Joshi 2002; Silori et al. 2005; GUIDE 2009). Of these *Citrullus colocynthis*, *Dactyliandra welwitschii*, *Ephedra foliata* and *Tribulus rajasthanensis* are lightly used, while *Commiphora wightii* is heavily exploited

**Table 4. Information on threats and total counts of RET plant affected**

RET plant species	Total	Stress											Total Affected	Total Rel %
		Anthropogenic						Natural						
		Cutting	Browsing	Encroachment	Habitat Degradation	Total	Rel %	Termites	Dry	Erosion	Total	Rel %		
<i>Campylanthus ramosissimus</i>	235		27		34	61	19.37	12	2	7	21	20.59	82	19.66
<i>Citrullus colocynthis</i>	65				16	16	5.08		9		9	8.82	25	6.00
<i>Commiphora wightii</i>	612	54	9	17	20	100	31.75	11		15	26	25.49	126	30.22
<i>Convolvulus stocksii</i>	127		23			23	7.30						23	5.52
<i>Dactyliandra welwitschii</i>	13													
<i>Dipcadi erythraeum</i>	9				2	2	0.63			2	2	1.96	4	0.96
<i>Ephedra foliata</i>	55				4	4	1.27			4	4	3.92	8	1.92
<i>Helichrysum cutchicum</i>	245				35	35	11.11		10	30	40	39.22	75	17.99
<i>Indigofera caerulea</i> var. <i>monosperma</i>	16													
<i>Ipomoea kotschyana</i>	440				70	70	22.22						70	16.79
<i>Pavonia ceratocarpa</i>	19													
<i>Sida tiagii</i>	37													
<i>Tribulus rajasthanensis</i>	43				4	4	1.27						4	0.96
<b>Overall total</b>	1916	54	59	17	185	315	100.00	23	21	58	102	100.00	417	100.00
<b>Rel % respectively</b>		17.14	18.73	5.40	58.73	100.00		22.55	20.59	56.86	100.00		21.76	



**Image 3. RET plants affected through various threats**

for local medicine.

It has been reported that a mature *C. wightii* (Guggal), can produce 250–500 of gum (Atal et al. 1975) and an estimated 300–400 tonnes of Guggal has been sold in Bhuj every year. However, this plant was found to be widely distributed in the study areas as well as in Kachchh. Crude methods of gum extraction from younger plants (Joshi et al. 2004) are likely to affect its abundance in the future. *C. wightii* is distributed in patches along the study area. This species, being one of the most valuable medicinal plants, needs special attention for its conservation in the wild as well as by promotion through cultivation. Furthermore, this species is endemic to arid and semi-arid regions of the Indian subcontinent (Bole & Pathak 1988; Dixit & Rao 2000; GES et al. 2002) and has been listed under promotional programmes of the National Medicinal Plant Board (NMPB), New Delhi. During surveys certain localities such as the site between Sanatorium (23°10'39.5"N & 69°38'35.4"E) and Tapkeshwari Mata Temple in Tapkeshwari MPCAs (Medicinal Plants Conservation Areas) were observed with large patches of *C. wightii*. Likewise, the site between geo-coordinates 23°11'43.6"N and 69°25'10.0"E to 23°11'37.6"N and 69°24'50.3"E within THR areas has abundant population of this species. These two sites may be identified for regulated harvesting and seed collection for ex situ conservation of this species by Gujarat State Forest Department.

Awareness of the rarity and the conservation significance of the different species should be created among the locals especially the native healers involved in using these medicinally important RET plants in tradi-

tional health care system for healing various types of diseases.

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**Author Details:** DR. P.N. JOSHI has a research experience of 12 years and published 48 research articles on plant ecology, participatory natural resource management and conservation. He is the registered member of IUCN – The World Conservation Union: Species Survival Commission Indian Subcontinent Plant Specialist Group (SSC-IPSPG) and Indian Association for Angiosperm Taxonomy (IAAT). DR. EKTA B. JOSHI, has a PhD in Plant Science (Ecology, Taxonomy and Conservation). She has research experience of five years and published eight articles in the fields of plant taxonomy, conservation of rare and endangered plants, ethnobotany among others. DR. B.K. JAIN, Principal in M.G.Science Institute, Ahmedabad and has a research and teaching experience of more than 20 years. He has published several books on vegetation science and is doing research in various branches of botany.