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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
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Cover: A digital art of water birds of Noyyal River and its wetlands in Coimbatore District by Megha A. Kashyap.

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COMMUNICATION

Evaluating the IUCN conservation status of *Tritaxis kurnoolensis* (R.R.V.Raju & Pull.) R.Y.Yu. & Welzen (Euphorbiaceae), an endemic tree species found in the Eastern Ghats region of Andhra Pradesh, India

Sarojinidevi Naidu [1] & **Raja Kullayiswamy Kusom** [2]

[1,2] Plot No. 95/1, Dharmavana Centre of Excellence for Biodiversity and Climate Resilience, Phase II, IDA, Cherlapalli, Hyderabad, Telangana 500051, India

[1] sarojini@DharmavanaNatureArk.org, [2] rajakswamy@DharmavanaNatureArk.org (corresponding author)

Abstract: *Tritaxis kurnoolensis,* a small tree of the Euphorbiaceae family, is endemic to a valley within the Sullavai Sandstone plateau in close proximity to the Paleru Reservoir (Owk dam). The species is a narrow endemic. No documented sightings of this species have been recorded beyond the type locality since its description in 1994 by Venkataraju & Pullaiah as *Dimorphocalyx kurnoolensis* from the Nandyal District of Andhra Pradesh. In this study, the authors applied the grid method for quantification and subjected the species to a meticulous analysis aligning with IUCN Red List Criteria. The distribution was found to be restricted due to habitat (valley) fragmentation, reservoir which is arresting seed dispersal, and destruction caused by tunnel construction civil works. The area of occupancy (AOO) at 16 km² and the extent of occurrence (EOO) at 0.474 km², were systematically computed using GeoCAT. The species is assessed here using the Red List methodology for evaluating extinction risk. Based on its AOO, EOO, and population size, it has been classified as Critically Endangered.

Keywords: Critically Endangered, endemic, grid method, Nandyal, Owk dam, quantification, small tree, sullavai sandstone, type locality, unisexual flowers.

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Author details: Dr. Raja Kullayiswamy FIAT, a Scientist at Dharmavana Nature Ark, Hyderabad, completed his PhD in botany from Sri Krishnadevaraya University in 2014. He has worked as a research associate at IISc, Bangalore, and is currently involved in biodiversity conservation with a non-profit society in Hyderabad. Dr. Raja, an invited reviewer for international journals, has published 20 research papers, described nine new taxa, and authored a book on the Tummalapalli Uranium Mining Area, Andhra Pradesh. Dr. Sarojini Devi is a research scientist at Dharmavana Nature Ark. She completed her PhD in 2015 from the Department of Botany, Sri Krishnadevaraya University, Anantapuram. After moving to Bangalore, she worked as a lecturer at MES Degree College, Malleswaram, and KLE Societies S. Nijalingappa College, Rajaji Nagar, Bangalore. Dr. Sarojini has published 19 research articles, described ten new taxa, and is an invited reviewer for international journals.

Author contributions: SD—writing draft, data analysis, photo settings. RKS—field data collection, data analysis, draft preparation.

Competing interests: The authors declare no competing interests.

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INTRODUCTION

Globally, there are 295,383 species and 13,164 genera of seed plants (Bramwell 2002; Govaerts 2003; Christenhusz & Byng 2016) among which 20% are threatened (Joppa et al. 2001). The majority of these are in the tropics and subtropics. Often, an overestimation of taxonomic or nomenclatural artefacts can be expected (Stefan 2004). As an example of this, Indian floristic studies have not been published with species distribution patterns and their endemism as a cumulative record for the entire geographical region except in old floras such as Flora British India (Hooker 1872–1897). The Botanical Survey of India (BSI) is trying to complete a set of volumes with detailed information on the species distribution and their endemism. However, over 75% of species are not covered.

There is ambiguity in the list of species which are endemic and Red Listed from India. According to Ravikanth et al. (2018), about 1,052 species are Red Listed of which 387 are plant species. Most of these 387 species are medicinal, among which 77 species are 'Critically Endangered' (CR). In the Western Ghats alone, more than 100 plant species of high economic importance are listed as threatened (Ravikanth et al. 2018).

There are many reasons for these species becoming threatened. India, like other countries, has had extensive developmental activities over the past few decades in forested areas. Railway lines, power grids, dams, and urban expansion have all taken their toll. The extensive exploitation of medicinal plants (collection of crude drugs), podu-cultivation, livestock grazing, dominant invasive species, and the disregard of government regulations have pushed endemic and threatened species to higher levels of risk. Immediate action is necessary to address these issues.

The IUCN Red List is centrally managed on a global level to address species conservation issues. Four entities are involved in the IUCN Red List Assessment process: (i) assessors, (ii) reviewers, (iii) Red List Authorities (RLAs), and (iv) the IUCN Red List Unit (RLU). Assessors gather data and apply the IUCN Red List Categories and Criteria to evaluate a species. Reviewers are independent experts who review the assessments before they are submitted for final checks. RLAs, which typically include IUCN Specialist Groups, Red List Partner institutions, or standalone Red List Authorities, are responsible for assessing species within their remit. The RLU acts as the gatekeeper for the Red List, ensuring that all published assessments meet the required standards (IUCN 2016).

The steps involved in the assessment are (i) data collection that is gathering data on species and identifying potential risks, (ii) initial assessment in which assessors apply the IUCN Red list categories and criteria, and (iii) peer review – an independent experts review to ensure the accuracy and consistency of the assessment. The assessment is submitted to the relevant RLA. Then, final checks are made by RLU to verify that all standards are met. Publication is the last stage where the assessment results are published on the IUCN Red List (IUCN 2016).

Baillon (1858) described the genus *Tritaxis* based on *T. gaudichaudii* Bail., which features three whorls of stamens in the type. Subsequently, two more species were published under the genus *Tritaxis*, but later they were transferred to other genera. For instance, *Tritaxis zeylanica* Müll.Arg. was moved as *Paracroton zeylanicus* (Müll.Arg.) N.P.Balakr. & Chakrab. and *T. macrophylla* Müll.Arg. became *Paracroton pendulus* ssp. *pendulus*, while establishing *Paracroton pendulus* ssp. *zeylanicus* (Thwaites) N.P.Balakr. & Chakrab.

The Dharmavana Nature Ark has undertaken the conservation of threatened woody species from the Deccan Peninsula and Eastern Ghats of India. The initiative began in 2004 by establishing a seedling nursery. This was followed by plantation of species to a 400-acre site where specific niches were designated for different groups of species.

During a visit to the type locality of *Tritaxis kurnoolensis* (R.R.V.Raju & Pull.) R.Y.Yu & Welzen (Yu et al. 2019) for seed collection, we were unable to find healthy seeds for nursery development. It was observed that individuals of the species were facing high stress and threat due to the dumping of stones and soil during the establishment of a reservoir (Image 2a vs b) and particularly so during the construction of inlet canals and the cutting of mature trees by the locals (Image 4a–f). Subsequent visits in 2023 aimed to understand the growth, survival, and recruitment as well as to obtain viable seeds. However, the attempts to establish seedlings were unsuccessful as the seeds were not viable (without kernal). Given the adverse conditions for species establishment through natural recruitment, special attention was given to conserving *Tritaxis kurnoolensis*, focusing on seed germination, air layering, and root cuttings collection. The focus now is on estimating the population size in the area and implementing conservation measures in a systematic, step-by-step manner.

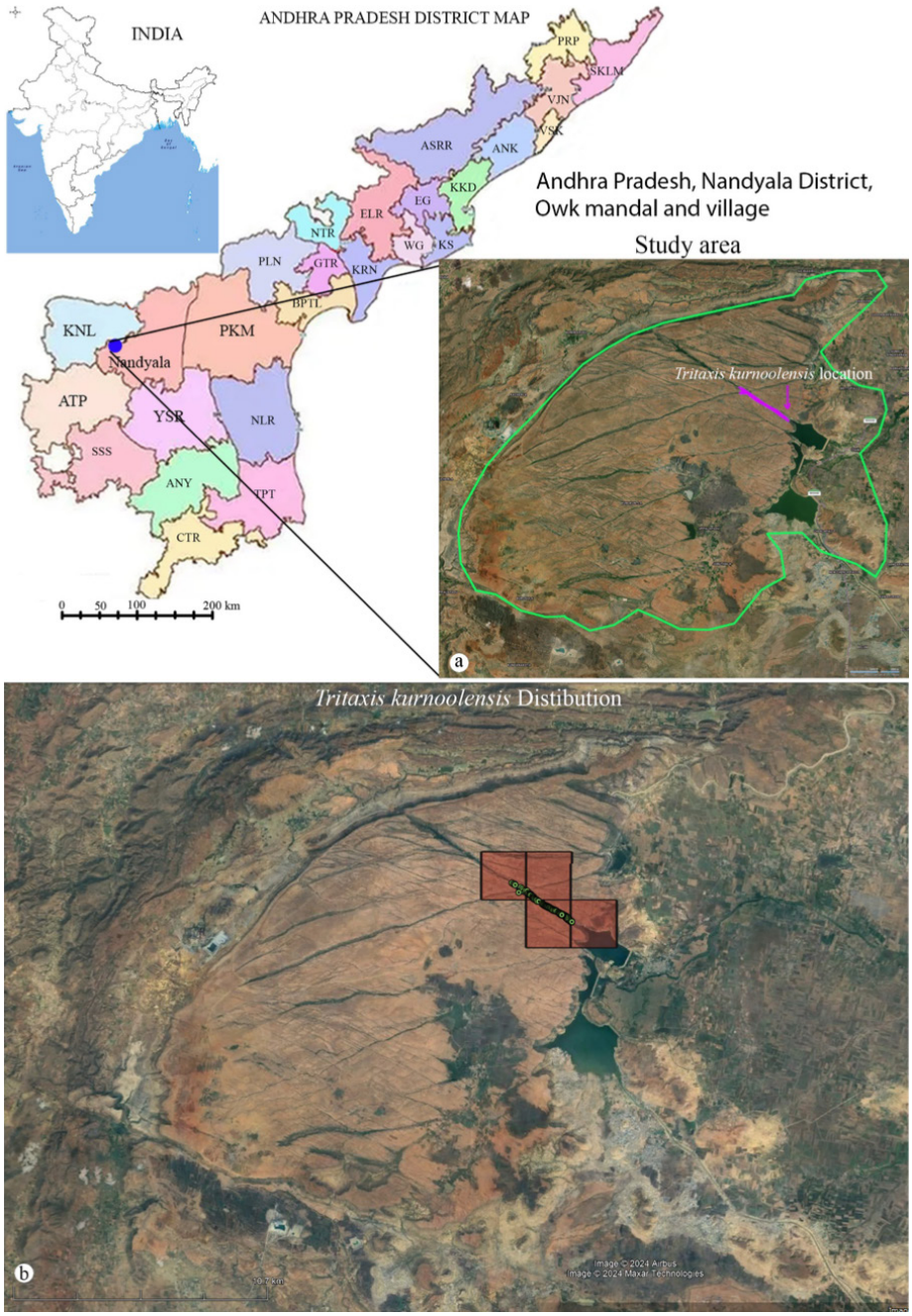

Image 1. Location of the rocky plateau study area of *Tritaxis kurnoolesi*: a—Isolated location of *Tritaxis kurnoolensis* (Green line- study area 286km^2, pink – single location) | b—Quantitative assessment (grid size 2 × 2 km).

MATERIAL AND METHODS

To measure the size of the population and the count of mature individuals, the authors categorized the habitat into four grids, each measuring 2 × 2 km as IUCN recommended and default option in the GeoCat. The presence of *Tritaxis kurnoolensis* was documented in each grid using covering a 10 × 10 m area. Across the four grids, a total of 85 quadrats were deployed, revealing a cumulative count of 164 mature individuals. The population within each specific quadrat was then determined. The locations of the taxon's occurrence were recorded using the global positioning system (GPS). For the IUCN Red List assessment, we employed GeoCAT (Geospatial Conservation Assessment Tool), an open-source tool used to calculate the taxon's extent of occurrence (EOO) and area of occupancy (AOO) based on GPS readings. These GPS readings, along with other

data such as catalogue ID, collector, country, event date, institution, locality, scientific name of the taxon, state, and elevation, were entered into a CSV file and uploaded to GeoCAT. A map was generated using GeoCAT (Bachman et al. 2011). This process is carried out in a transparent, repeatable, and rapid manner within a user-friendly interface, as described by Bachman et al. (2011). Based on the initial assessment in the study area, the EOO and AOO for this taxon were approximated in square kilometers (Figures 1 & 2).

RESULTS

Tritaxis kurnoolensis (R.R.V.Raju & Pull.) R.Y.Yu & Welzen (= *Dimorphocalyx kurnoolensis* R.R.V.Raju & Pull. Botanical Bulletin of Academia Sinica 35: 201 (1994))

Monoecious deciduous small trees, up to 4-m high, bark dark brown, scaly, blaze light yellowish-brown, branches terete, striate, pubescent. Leaves glabrous, 5–15 × 3–7 cm, elliptic-oblong or obovate, base attenuate, margin entire–sinuate, apex sub-acute obtuse; lateral veins up to nine pairs; petiole up to 3 cm, shallowly channeled above; stipules deltoid. Inflorescens terminal, lax receme. Male and female inflorescences on different branches of same plant, diclinous flowers (Figure 3). Male flowers cymose clusters on terminal pubescent peduncle; peduncle up to 7 cm long; flowers subsessile, 4–5 mm cross, ovate bud, pedicels to 2 mm long, bracts lanceolate, 1–2 × 2–3 mm, densely pubescent, acute-acuminate; tepals in two whorls (5 + 5); outer green (sepals), cupular, 5-lobed, connate, adpressed-pilose, lobes subovate orbicular; inner (petals) white, polypetalous, each oblong, obtuse, often emarginated, bent out. Stamens biseriate, 5+11–17; outer five basally connate to the inner staminal column, filaments 1.8 mm; anthers 1.2 mm across, widely oblong; inner (11–17) stamens on 7 mm long staminal column with their individual 0.5 mm long connectives; anthers 0.8 mm across, monodelphous, orbicular, acute; disc glands 5, free, ovate-oblate, hairy at top. Female flowers few, in short pedunculate racemes; flowers 5–8 mm across; pedicel 8mm long, pubescent; tepals in two whorls (5+5); outer (sepals) green, cupular, shortly 5-lobed, connate at base, adpressed-pilose without; lobes suborbicular, 2 × 2.5 mm; inner (petals) white, polypetalous, oblong-obtuse, often emarginated; ovary 4 × 3 mm, adpressed-pilose, three locular; styles 3, connate at base, each 2-fid from above the middle, papillose; disc glands as in the male flower. Capsule 1–1.3 × 1.3–1.7 cm, sub-globose, depressed, adpressed-pilose, 3-lobed, deeply furrowed, fruiting calyx (sepals) deeply 5-lobed, lobes 5.5 × 3.5 mm, adpressed-pilose without. Seed shiney, 8 × 7 mm, elliptic-oblong, brown mottled with grey, tips acute, hilum circular, testa smooth, ecarunculate (Image 1). Flowering is in December–March and fruiting in February–April.

Habitat and Distribution

Tritaxis kurnoolensis is endemic to a valley where there is sullavai sandstone (as surface stone). We chose the entire plateau of around 286 km^2 as a study area for the present taxon IUCN assessment. This species is associated with *Ziziphus oenopolia* (L.) Mill., *Grewia damine* Gaertn., *G. flavescens* Juss., *Ficus mollis* Vahl, *Pterospermum xylocarpum* (Gaertn.) Oken, *Ixora pavetta* Andrews (= *Ixora arborea* Roxb. ex Sm.), *Vitex leucoxylon* L.f., and *Tamarindus indica* L. *Tritaxis kurnoolensis* is distributed in only one valley even though there are four valleys in the study area.

This species has been in continuing decline because of reservoir and tunnel construction. Prior to construction, trees likely lined the natural, original water stream. Unfortunately, these water streams were converted into canals for irrigation purposes resulting in a significant loss of habitat and trees. This impact is

Table 1. Number of mature individuals of *Tritaxis kurnoolensis* counted in the study area.

Grid ID	No. of individuals from 5 quadrants in a grid	No. of individuals in whole grid (200 × 200 m)
1	20	23
2	6	6
3	27	46
4	20	21
5	8	8
6	18	29
7	13	22
8	4	4
9	10	11
10	8	8
11	10	15
12	8	8
13	1	1
14	2	2
15	5	5
16	3	3
17	1	1
Total	**164**	**213**

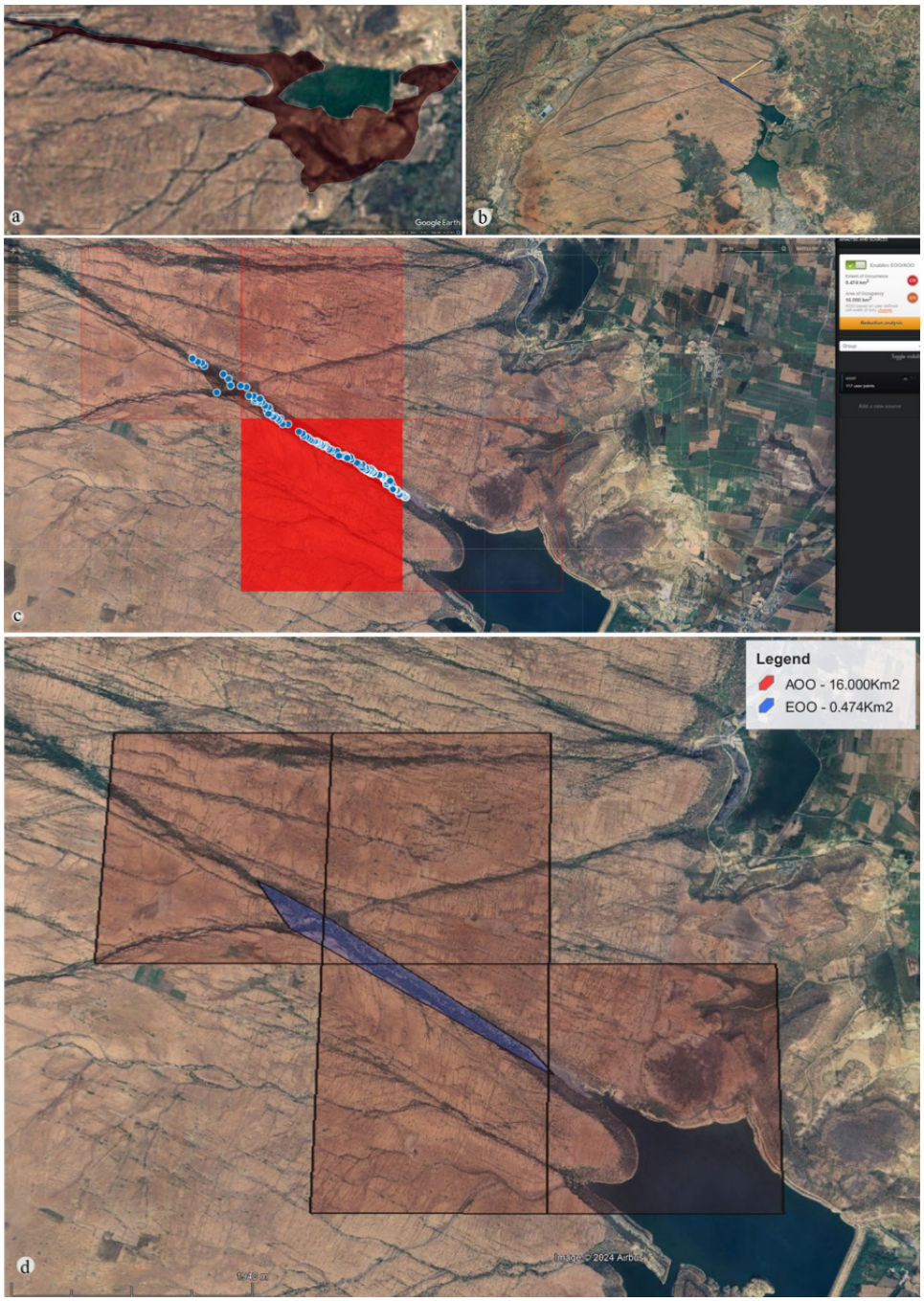

Figure 2. Faunal composition as reported from the rocky outcrops off the coast of Gopalpur (Odisha/ NW Bay of Bengal). SC—Soft Coral | HC—Hard Coral | Anti.—Antipatharian | Hyd.—Hydroids. Data obtained from Rao et al. (2001).

particularly apparent following dam construction since the natural dispersion of seeds and recruitment for the next generation were severely depressed (Image 2a–f).

Threats

The seeds of this species disperse through an explosive fruit mechanism at drying, contributing to a low probability of horizontal spreading. Seeds disperse over a maximum radius of 5 m from the mother plant. Seeds are relocated by rainwater and some may decompose in the reservoir. Mature stems are harvested for firewood and serve as support sticks for banana plants. Additionally, waste stones are dumped into the area due to water inlet (tunnels which connect to the Gorukallu balancing reservoir about 60 km away) development activities (Image 4). Owk reservoir development commenced

in 2003, greatly enlarging what was initially two large ponds utilized for agricultural purposes.

IUCN Red List Assessment

Tritaxis kurnoolensis is restricted to a valley of the sandstone plateau of the Paleru reservoir (Owk dam) area, Nandyal District, Andhra Pradesh, India (Image 1a,b). Based on the distribution of the taxon and the decline in the number of individuals since 1994, its habitat area has decreased from 3.48 km² to 0.474 km². In addition to ongoing threats such as forest fires, reduced production of healthy seeds, and inadequate conditions for seed germination, there is now a significant additional threat from waste stone dumping on individuals confined to the valley. Considering these factors along with the AOO and EOO values, population size, and number of locations, we have evaluated its conservation status. Notable data parameter the EOO at 0.474km² is calculated using a minimum convex polygon (MCP). The IUCN threat status is classified under 'Critically Endangered' (CR) following IUCN (2022), verson 15.1 guidelines, B1ab(i,ii). This species meets B1- Extent of occurrence (EOO) is less than 100 km² (Image 2), B1a – number of locations is 1 (Image 1a), B2b (i) – decline in extent of occurrence (Image 2a *vs* b), (ii) – decline in area of occupancy since 1994 (Image 2a vs b) from 3.48 km² to 0.474 km². Taking these criteria, we concluded the species IUCN Red List threat status as 'Critically Endangered'. There is an immediate need to plan in situ and ex situ conservation of this species. Research to monitor trends in population decline and stop the threats are imperative.

Conservation Action

The Dharmavana Nature Ark team conducted several seasonal visits from January 2023 to gather healthy seeds. However, due to the lack of properly formed seeds, they initiated a regeneration strategy via vegetative propagation such as air layering. The objective is to successfully cultivate at least 10 individuals from various mother plants. Once these plants thrive in pots, they will be transplanted to appropriate microhabitats within the Dharmavana Nature Ark ecosystem that has been strategically designed to accommodate different plant groups based on their original habitats (Image 4).

DISCUSSION

The population of *Tritaxis kurnoolensis* is declining due to habitat fragmentation and destruction caused by tunnel construction and reservoir civil works. The species has become a narrow endemic, largely confined to a small area. Its decline has been ongoing since 1994, following the conversion of two ponds into a dam. Previously, the species was found along the bunds of the two ponds and the canals that directed water to agricultural fields. However, with the expansion of the ponds and the renovation of the canals, much of its habitat has been lost. In addition to the dam's construction, two connecting tunnels from the Gorukallu Balancing Reservoir, about 60 km away, have also contributed to its decline. During the excavation of these tunnels, waste soil and stone were dumped on *Tritaxis kurnoolensis* individuals, leading to the trapping and drying out of many plants in recent years. We suspect that diminishing population sizes coupled with human-made threats and habitat fragmentation have driven species far below sustainable levels. Based on fruit setting and seed germination percentages, we also suspect that inbreeding, loss of pollinators, and climate change are contributing to the species' extinction (Image 2a,b; Image 4). No documented sightings of this species have been recorded since 1994 beyond the type locality from the Kurnool District (now the area comes under newly formed Nandyal District) of Andhra Pradesh. GeoCAT analysis reveals a small AOO (16 km²), EOO (0.474 km²) and number of individuals less than 250, categorizing the species as Critically Endangered. Urgent conservation action is recommended by Dharmavana Nature Ark and the authors to save this species, as the number of individual trees counted 213 (Table 1).

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Image 3. a—Habit of a healthy undamaged tree of *Tritaxis kurnoolensis* | b—Habit of a damaged tree with cluster of stems | c—Male flowers and healthy leaves | d—Female flowers | e—Fruiting branch | f—Mature fruits | g—Seeds. © RajaKswamy.

Image 4. Threats to *Tritaxis kurnoolensis*: a—Trees dying from fallen rocks | b, c—Cluster of stems covered by dumped stones | d—Root system of the tree damaged by soil erroson | e—a tree in the valley among the waste stones | f—Tree fall due to the weight of stones dumped on it | g—Air layering. © RajaKswamy.

Image 5. Male and female flowers on the same tree of *Tritaxis kurnoolensis*. © RajaKswamy.

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ravi@threatenedtaxa.org & ravi@zooreach.org

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