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Pterocarpus santalinus, Red Sanders

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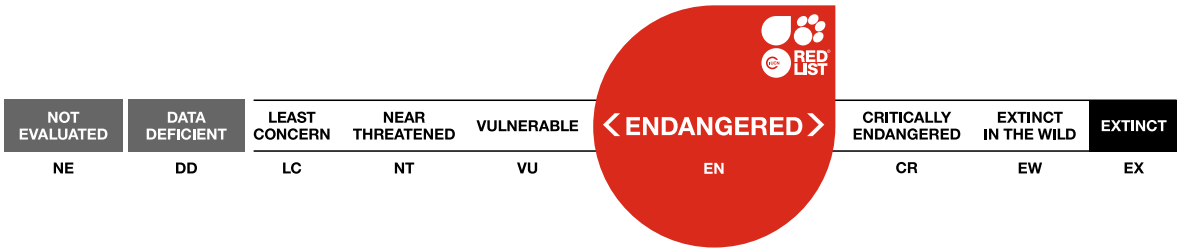

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Taxonomy

Kingdom	Phylum	Class	Order	Family
Plantae	Tracheophyta	Magnoliopsida	Fabales	Fabaceae

Scientific Name: *Pterocarpus santalinus* L.f.

Synonym(s):

- *Lingoum santalinum* (L.f) Kuntze

Common Name(s):

- English: Red Sanders, Almug, Red Sandalwood, Saunderswood
- Gujarati: Ratanjali
- Hindi: Lal Chandan, Lal Chandan, Raktachandan, Undum
- Kannada: Kempujandha, Raktashandana
- Malayalam: Chenchandanam, Chenchandanam, Rakthachandanam, Rakthachandanam
- Marathi: Ratanjan
- Sanskrit: Agarujandha, Arka, Chandana, Harichandana, Tilaparni
- Tamil: Semmaram, Sivappuchandanam
- Telugu: Yerrachandanam

Taxonomic Source(s):

Board of Trustees, RBG Kew. 2021. Plants of the World Online Portal. Richmond, UK. Available at: http://www.plantsoftheworldonline.org.

Assessment Information

Red List Category & Criteria: Endangered A2cd ver 3.1

Year Published: 2021

Date Assessed: October 20, 2020

Justification:

Pterocarpus santalinus is an Indian endemic tree species, commonly known as Red Sandalwood or Red Sanders. It has a restricted geographic range in the Eastern Ghats where the species is endemic to a distinct tract of forest in the state of Andhra Pradesh. The species is estimated to have an extent of occurrence (EOO) of up to 20,000 km^2 and area of occupancy (AOO) of just over 1,000 km^2. Despite intense harvest of the species since the 16th century it has mostly retained this geographic range. However, over this time the population has experienced a severe decline. This is due to the continual illegal harvest of the species driven by high demand for its attractive heartwood and the high-value products made from it. The over-harvest of the species has left the population structure skewed, with trees of harvestable size and maturity being scarce and making up less than 5% of the trees remaining in the wild. The species is theoretically banned from international trade, being listed under Appendix II of CITES, while the harvest of the species is restricted at the state level through legislation. However, there is still an illegal harvest and trade of the species to meet the global demand. This is evidenced by the large volume of timber and Red Sanders products seized by authorities at all stages of the illegal supply

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chain and also the observation of freshly cut stems in all forest divisions where the species is found. The decline in the mature population size and limited regeneration potential and a reduced seed set of the species can contribute to genetic erosion in the future. Pressure on the wild population leaves no time for the species to recover naturally, which is exacerbated by the slow growth rate of the tree. The Red Sanders trees are at further risk from anthropogenic habitat loss caused by local cattle grazing and use of the forest for local timber and fuelwood. Trees may also be outcompeted by invasive species and are threatened by invasive pests and diseases. All these threats culminate in a dwindling wild population and, therefore, it is suspected that over the last three generations the species has experienced a population decline of 50 to 80%. It is assessed as Endangered.

The species is protected in some protected areas and *ex situ* cultivation. There are also International, National and State level laws which prevent cutting and transport of the species. There are also physical deterrents and patrols in place in Andhra Pradesh which have been barely successful in reducing the smuggling of the species. These conservation efforts should remain in place and be further strengthened and developed, to reduce smuggling further. The cultivation of the species in plantations should be promoted needs proper monitoring and management so as to be able to better support the legal trade of the species as well. Also opportunities to increase the harvest and trade of cultivated stock should be investigated to relieve some of the pressure on the wild Red Sander population.

Previously Published Red List Assessments

2018 – Near Threatened (NT)
https://dx.doi.org/10.2305/IUCN.UK.2018-1.RLTS.T32104A67803072.en

1998 – Endangered (EN)
https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T32104A9679328.en

1998 – Endangered (E)

Geographic Range

Range Description:

Pterocarpus santalinus is endemic to the Eastern Ghats, in India where it has a very restricted geographic range.

Generally, the species is considered native to only Andhra Pradesh (Hedge *et al.* 2012, Arunkumar and Joshi 2014, Ahmedullah *et al.* 2019, Pullaiah *et al.* 2019) and this is the range used for this assessment. It is recorded as naturalised to Tamil Nadu as the origin of individuals here are from planted individuals. The same is true for Karnataka (Ahmedullah *et al.* 2019). These two states are not included in the native range of the species for this assessment.

Within Andhra Pradesh the species is known from Palakonda and Seshachalam hill ranges of Kadapa (formerly Cuddapah), Chittoor, Prakasam, Nellore and Kurnool districts (Hedge *et al*. 2012, Arunkumar and Joshi 2014, Ahmedullah *et al.* 2019).

Red Sanders are considered to occupy a zone between 13° 3′ and 15° 0′ Latitude North and 78° 45′ and 79° 39′ Longitude East (Pullaiah *et al*. 2019). This gives an estimate for extent of occurrence of just over 15,000 km^2. The recently completed Non-Detriment Findings (NDF) (Ahmedullah *et al.* 2019) of the

species, which included survey of 616 sites in the range of the species of and identified 344 of these sites to contain Red Sanders trees, give an extent of occurrence of 19,655-19,675 km^2 and an area of occupancy of 1,068 km^2. It is noted that many of these trees are not mature individuals within the documentation. It is these later measures that are used for this assessment.

The species is cultivated within Sri Lanka, China, around its wild range states and also in Kerala, Maharashtra, Gujarat, Karnataka, Telangana, Tamil Nadu, Odisha and West Bengal within India.

Country Occurrence:

Native, Extant (resident): India (Andhra Pradesh)

Population

The population of *Pterocarpus santalinus* is in decline. This is predominantly caused by the current illicit harvest and trade of the species driven by high international demand for the coloured heartwood the species produces. Other factors such as anthropogenic pressure on Red Sanders forest, biological vulnerability to over harvest (leading to low fruit set etc.) and risk of fires in the species' natural habitat also lead to the decline in the population of the species (Ahmedullah *et al.* 2019). While reviewing the population trend, Ahmedullah *et al*. (2019) noted that trees of higher girth class (>70 cm) are widely scattered in its natural range or even absent in some areas that have been subject to rampant illicit felling. On a broad analysis, it is estimated that about 1,550,936 (15,50,936 lakh) harvestable trees may be found in the Red Sanders bearing forests covering an area of *c*. 398,203 (3,98,203 lakh) ha, of which *c*. 168,118 (1,168,118 lakh) ha comes under the Protected Area Network of Andhra Pradesh. It is roughly estimated that about 903,614 (9,03,614 lakh) trees are in the reserve forest areas outside the PAs. On rough computation, it is feared that on an average only two to three harvestable trees per ha may now be found in the Red Sanders forest areas outside the Protected Areas.

The species has featured in the trade since the 16th century, where Red Sandalwood timber was sold to Europe and used as a dye (Teixeira da Silva *et al.* 2018). In the last few centuries, the trade of the species has remained consistent, with demand changing for use of the species for the dye to use of the timber for furniture production and other goods as well as medicinal uses. With this, the primary market has moved from Europe to other parts of the globe, in particular Japan and China (Mulliken and Crofton 2008). At the beginning of the trade of the species in the 1500s harvest was unrestricted. Restrictions first came into place in the 1920s. Therefore, much of the trade of the species is now illegal, with smuggling occurring due to the high value and demand of Red Sanders timber in the global market.

Despite the listing of the species under CITES and protective laws at the National and State level illegal cutting and trade of the species is still prolific. This is evidenced through the continual seizure of Red Sanders timber and products by local authorities. In 2004, a reported 2,381 MT of Red Sanders timber was seized in Singapore (Mulliken and Crofton 2008). The most recent relaxation of trade laws to sell seized Red Sanders timber saw the sale of over 10,184 MT (Ahmedullah *et al.* 2019). The volume of timber seized at the point of exports and other stages of the supply chain illustrates considerable depletion of the Red Sanders trees in the wild (Ahmedullah *et al*. 2019).

Trade of the species has been historically well documented (compared to other timber species), with a record of 15,585 MT traded between 1882 and 1883 (Ahmedullah *et al.* 2019). In the 20th century, the volume of Red Sanders traded is thought to have peaked in the 1970s where 444 MT was traded in 1973 but due to reduced wild stock availability annual trade has since been lower (Mulliken and Crofton 2008). In 1983, 100 MT was traded and on average across the 1990's, 76 MT was traded annually (Mulliken and Crofton, 2008). In 1998, the Mumbai company was stated to have considered the stock of *P. santalinus* to have been 'dwindling for the past 18 years' (Mulliken and Crofton, 2008), showing a decline in stock at the end of the last century.

Across the last century, the tree has been introduced to different plantations, wood farms and forests to be cultivated. It is hoped that these cultivated sites could one day meet the international demand for Red Sanders timber. However, currently, owing to the long regeneration length of the species, they do not (Ahmedullah *et al.* 2019). Due to this, there is still a high demand for wild-sourced timber. It is

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therefore essential that cultivated Red Sanders are well managed to meet the international demand as far as possible in the present day and into the future. Demand for timber is such that the wild and cultivated supply cannot meet the volumes needed. Due to this, it is therefore feared that decline is continuing as demand shows no signs of ebbing and illegal felling still continues unabated.

Currently, there is no forest or harvest management of Red Sanders (Hedge *et al.* 2012). The species is slow-growing, taking several decades to mature and reach harvestable girth at breast height (estimated to be 80 to 100 years to reach good harvestable size) (Ahmedullah *et al*. 2019). Therefore, the tree is predisposed to decline as it is unable to recover from intense logging activity. This is shown in the skewed population structure of the species, which is common to an unsustainably harvested tropical hardwood trees. Disturbed areas of Red Sanders forests are found to have a 'reverse J' population structure, with small trees under 50 cm girth at beast height (gbh) being more common than those of larger gbh (Rao and Raju 2002).

For the latest Non Detriment Findings (NDF) study completed by Ahmedullah *et al*. (2019), 616 sites within the native range of *P. santilanus* were surveyed, across all districts and forestry divisions where the species is native. Of the 616 sites only 344 were found to have remaining subpopulations of Red Sanders. Compared to the 2012 findings (Hedge *et al*., 2012), three sites previously known to include Red Sanders trees no longer had individuals of the species (Ahmedullah *et al*. 2019). Across the survey sites, the percentage of harvestable trees (those over 50 cm gbh) was calculated to be only 3.9%, a decline from 7.8% in 2012. The majority of trees were of non-harvestable size, with 72% of trees less than 40 cm gbh and only 2.19% of trees being above 70 cm gbh and only 0.61% over 90 cm in gbh (Ahmedullah *et al.* 2019).

At a forest division level, the species is a dominant tree in Kadapa, Rajampet and Proddatur divisions, where upon survey Red Sanders trees were found in the majority of sites and concluded to be the dominant tree species. The tree was less common in Tirupati, Chittoor East and Nellore and only considered sporadic in Giddalur and Nandyal divisions (Ahmedullah *et al*. 2019). In each site, the majority of Red Sanders trees (always over 80%) were below 50 cm gbh and only very low percentages were above 70 cm gbh (Ahmedullah *et al*. 2019). In Nandyal Forest Division no trees over 70 cm gbh were found, while in Rajampet Forest Division, where trees are older, a large proportion of trees are of harvestable size.

Red Sanders are only considered to have survived centuries of harvest due to having naturally good regeneration and coppicing, which is now a feature of heavily logged areas (Ahmedullah *et al*. 2019). Despite this the fruit set of the species is low. It is thought that fruit set may continue to be poor in the future, as the gene pool for the species and the potential for outcrossing becomes less as fewer trees are available for cross-pollination leading to a higher rate of seed abortion due to a higher occurrence of selfing (Ahmedullah *et al.* 2019). Climate Change can also reduce access of pollinators to the tree reducing cross-pollination further. Selective felling has also impacted the regeneration of the species, as there is reduction of higher girth class trees and adaptation to new altered conditions (Ahmedullah *et al*. 2019). Therefore, there is a fear of a genetic bottleneck or genetic erosion for the species. Selective felling also creates a situation that is more susceptible to a forest fire. This can damage and cause a lessening of mature trees and also cause greater thinning of seedlings to the mature stages of the life cycle (Ahmedullah *et al* 2019). Harvesting also occurs at such a high rate that even where regeneration is good it is not possible for replenishment to occur, especially considering the length of time it takes for

maturation.

The species is also threatened by habitat degradation, loss and alteration. As mentioned earlier, one driver of this is a more frequent forest fire. The recent NDF survey (Ahmedullah *et al*. 2019) also found evidence of livestock grazing and leaf collection from the tree by local communities. There is also risk from the expansion of cash crops and fuel wood collection (Mulliken and Crofton 2008). This may deplete the habitat available for the species to regenerate in, causing a further inability to reproduce.

Despite listing of the species in CITES Appendix II in 1995, there is still rampant and wanton harvest of the species, which follows centuries of overexploitation of Red Sanders forests (Ahmedullah *et al*. 2019). This is evidenced by large numbers of stumps observed during the recent NDF surveys (Ahmedullah *et al.* 2019) and the observation of smugglers during these surveys and the high volume of seizures of illegally harvested timber. The volume of Red Sanders timber available to harvest is obviously depleting. As demand for Red Sanders timber is not diminishing and even a combination of the commercial and wild harvest is not considered to meet the demand, the wild population of the species is under a serious threat in the wild.

Given the evidence of continuous unsustainable and illicit harvest of the species, and ongoing threat to Red Sanders forest it is inferred that over the last three centuries (three generations for the species) that population decline for the species is between 50 and 80%. Further more, according to the recent NDF study (Ahmedullah *et al.* 2019) only 2.19 percent of the wild populations of Red Sanders have been found to be harvestable (>70 cm girth). The earlier NDF study (Hegde *et al.* 2012) showed that only 5.7 per cent were harvestable. This indicates that Red Sanders populations have declined rapidly over the last 5-6 years. This is indicative of a situation where the continuous declining trend in the populations has picked up pace during the last few years leading to high severity of threat due to overexploitation and other anthropogenic factors.

Considering that decline of the population is continuing, cultivation of the species from non-wild stock is encouraged to continue to meet global demand for Red Sanders timber, while the remaining wild population requires strict conservation to support a diverse ecosystem and gene pool. All current conservation policies and strategies should remain in place and be expanded to support the remaining wild population of the species and prevent any additional or unsustainable decline.

Current Population Trend: Decreasing

Habitat and Ecology **(see Appendix for additional information)**

Pterocarpus santalinus is a medium-sized tree species between 10 and 15 m in height (Arunkumar and Joshi 2014). It grows in dry deciduous forests where it can be mixed with other native species or form pure stands (Babar *et al*. 2012). The species has a narrow specificity, with the majority of stands occurring on quartzite soil. It grows on dry, hilly zones often on rocky ground (Rao and Raju 2002). The species is most frequent on hillsides and plateaus (Ahmedullah *et al*. 2019). The optimal elevation range for growth is between 300 and 600 m above sea level, with numbers increasing with elevation until 650 m asl; from here there is a decline in abundance up to higher elevations (Ahmedullah *et al*. 2019). The species is light-demanding and cannot tolerate shade or water logging (Arunakumara *et al*. 2011). The trees are vulnerable to disturbance, forest fire and changes to climate (Ahmedullah *et al*. 2019).

The species is slow-growing taking 80 to 100 years to reach good harvestable size. The trees are pollinated by bees. The pollination ecology of the species can be affected by climate; in the hottest times, the trees cannot be visited by bees at which point outcrossing is reduced and there is a higher occurrence of self-pollination (Rao and Raju 2002). When trees self-pollinate there is a higher rate of seed abortion, contributing to the low fruit set of the species (Rao and Raju 2002). Low fruit set is also attributed to a smaller mature tree population caused by logging. Fruit ripens from February to March. The fruit is wind-dispersed and seed germinated quickly after the rainy season.

Systems: Terrestrial

Use and Trade

Pterocarpus santalinus is a very valuable, attractive, hardwood species. Timber is derived from the heartwood of the species for its colour and is used to make furniture, musical instruments, carvings and to make agricultural tools. It is commonly known as Red Sanders or Red Sandalwood. The wood is in high demand globally, particularly in Japan and China, but was earlier sought in many parts of Europe (Arunkumar and Joshi 2014) for the production of dye, not timber.

International trade of the species began in 16th Century, with trade occurring with Europe for the use of the species in dying processes (Ahmedullah *et al.* 2019). Trade with Europe continued for a few centuries, with records of 12,782 MT traded to the UK, 1,116 MT traded to France and 1,687 MT traded to India and Sri Lanka between 1882-1883 (Ahmedullah *et al*. 2019). At this time the use and trade of the species were unrestricted. However, since 1927, the species has come under national and international legislation, to limit the harvest of the species. Also in this time, the shift in demand for the species moved from dye to timber and from Europe to East Asia and other parts of the globe. Trade of the species is now monitored and has been for several decades, and with the placement of the species in Appendix II of CITES quotas and permits are now used to restrict the trade of the species (Ahmedullah *et al*. 2019). The current quota, since the listing of the species under CITES in 1995 has been variable but since 2012 it has been set at 310 MT prior to this it is thought that 5,900 MT was annually traded. To internationally trade the species an export license is required, a certificate of origin and date of procurement as well as other details (Ahmedullah *et al.* 2019).

Despite the legislation, illegal and illicit cutting and trade of the species is rampant. This is driven by high international demand of the species and high value of the timber. Since the origin of the trade of the species, timber value has increased by USD $150,000 per cubic metre (Ahmedullah *et al.* 2019). Current market value per tonne of Red Sanders timber is Rs 40 Lakhs (equivalent to USD $58.040) (Ahmedullah *et al.* 2019). There is some legal trade of the species from products seized at different stages of the illegal supply chain, these points of trade only occur when there are windows of ‘relief’ every few years which are put in place to sell seized goods and wood. Each state that seizes Red Sanders timber and products is entitled to the sale of these items through auction. Across the states in this last window, 10,184 MT of confiscated Red Sanders was sold (Ahmedullah *et al.* 2019). Almost all the seizures indicate the movement of logs towards the exit points or the seizures themselves are at the exit points during attempted smuggling (Rao and Raju 2002, MoEFCC 2018).

The desirable heartwood of this tree takes between 18 and 22 years to form and the species is generally not considered harvestable, with adequate quantities of heartwood until it is 70 to 80 years old (Ahmedullah *et al.* 2019). Optimal girth at breast height (gbh) for heartwood harvest is over 70 cm but

such is global demand for Red Sanders timber, smaller trees are also cut (Ahmedullah *et al*. 2019). Trees may also be debarked by smugglers to check if heartwood is present and this, in turn, damages the tree and makes it susceptible to infections (Ahmedullah *et al.* 2019). There is no commensurate replanting in the wild (Ahmedullah *et al*. 2019) and the species takes a long time to regenerate, therefore, the current demand and harvest of the species is unsustainable.

The species is found in numerous private and Government-owned plantations. These can be found in Andhra Pradesh, Tamil Nadu, Karnataka, West Bengal and Telangana (Ahmedullah *et al.* 2019). Plantations are most numerous and largest in Tamil Nadu, with the fewest found in Karnataka (Ahmedullah *et al*. 2019). Although outside the species native range plantations in West Bengal perform well though the heartwood produced can be paler, as growth is not in optimal conditions (Ahmedullah *et al*. 2019). Plantations that have been established in the early to mid 20th century have large trees that are near harvestable while in some areas planting is new and fresh and the species will take several decades to be mature and be ready for harvest. It is thought that at least a 40 to 50-year rotation cycle is needed (Ahmedullah *et al.* 2019), demanding high upfront costs and slow gain back of value.

Trade from plantations is now limited by CITES as many of the plantations were established from wild-sourced material. Currently, there is a national quota of trade of 310 MT which is split between Tamil Nadu and Andhra Pradesh which have the largest cultivated stock (Ahmedullah *et al*. 2019). It is thought that increasing the harvest and trade of cultivated stock would relieve some of the pressure on the wild Red Sander population. This needs to be managed sustainably with regular assessment of the stock, with the quota varied accordingly to prevent over harvest. Rotations and planting would also need to be implemented (Ahmedullah *et al.* 2019). Wood farms and plantations established from 'artificial' sources, e.g., using seed and cutting from plantations also needs to be developed (Ahmedullah *et al.* 2019) so that trade from cultivated sources is less restricted.

The species has negligible utilisation within the country, mainly in Ayurvedic pharmacopoeia and sometimes for making small toys and musical instruments such as the 'shamisen'. Locally, leaves are collected and used as fodder for livestock and communities during the lean months of the year (Ahmedullah *et al.* 2019). Domestically, in the 1990s only 5% of trade in *Pterocarpus santalinus* was for the domestic market while the rest was internationally exported. The species has virtually no domestic demand for construction or furniture use. However, in the Proddatur forest division local communities are thought to depend on Red Sanders for their livelihoods. The Jawadi and Malyali tribes, residing in Thiruvannamalai and Vellore districts of Tamil Nadu, who are traditional hunters and woodcutters, derive income from the smuggling of timber (Ahmedullah *et al*. 2019).

The species may also be harvested for pharmaceutical and medicinal uses. The heartwood can be powdered to produce a treatment for diabetes. The species is used for immunity medicine in China. The wood is astringent which can help alleviate swelling, pain and reduce bleeding (Rao and Raju 2002). The species also produces a red dye known as 'santalin' this has medicinal properties but is also used to dye paper, pulp, textiles and for tanning (Prakash *et al*. 2006, Arunakumara *et al*. 2011, Pullaiah *et al.* 2019).

Threats **(see Appendix for additional information)**

Recognizing the increasing threat to the species due to illicit felling the alarm bells for its impending depletion were sounded way back in the 1980s (Ahmedullah and Nayar, 1984, 1987). The single greatest threat to the Red Sanders population is illicit felling for smuggling, besides forest fires, cattle grazing and

other anthropogenic threats. This over-extraction has been occurring for several centuries and has caused severe depletion of the species in the wild. Continuous international demand and the value raised from the sale of Red Sanders timber means it is continually logged, even in the face of state, national and international level protective legislation. The volume of timber logged is evidenced in the frequency of stumps found across all forestry divisions where the species is native (Ahmedullah *et al*. 2019) and the volume of timber that is seized at different points along the illicit supply chain of the species (Ahmedullah *et al*. 2019). The species is slow-growing and has a naturally low seed set and, therefore, is predisposed to decline from timber harvest as it is not able to regenerate quickly and needs long rotation periods between harvests (Ahmedullah *et al.* 2019). This is particularly of note as there has been virtually no commensurate planting, and therefore the wild population has suffered further.

Trees are cut at all size classes, to meet the demand for heartwood even though harvestable size is thought to be over 70 cm girth at breast height (gbh). Already between surveys in 2012 and in 2018-19 the volume of harvestable sized trees has decreased from 7.8% to 3.9% and in all forest plots surveyed in 2018-19 fewer than 5% of trees had a gbh of over 70 cm and the majority of trees were less than 40 cm gbh (Ahmedullah *et al*. 2019). The dominant removal of the largest trees has caused the population structure of the species to become skewed and is described as a reverse-J structure (Ankalaiah *et al.* 2017). The illegal trade adversely affects the population structure of the species with the removal of superior phenotypes. This means small, immature trees are more abundant in the population reducing the regeneration potential of the tree. With the population containing fewer mature trees, there is a higher occurrence of self-pollination and therefore a higher rate of seed abortion (Rao and Raju 2002), contributing to a lower seed set and potential genetic erosion.

The species is widely cultivated, and it is hoped that these planted trees can ease the pressure of harvest on the wild population. However, the trade of cultivated specimens from wild origin is restricted (Ahmedullah *et al.* 2019). Unfortunately, the off-take from cultivation is not as high as hoped and this should be rectified. These plantations need well-enforced management to prevent over-harvesting and increase planting from artificial sources (Ahmedullah *et al*. 2019) to maintain a constant supply of cultivated trees. Currently, cultivation cannot currently meet international demand it is feared that the species will remain threatened by illegal logging (Mulliken and Crofton 2008). However, cultivation of Red Sanders is now being encouraged by the state forest departments in India (Ahmedullah *et al.* 2019).

Locally, leaves of the species can be utilised as fodder for livestock and communities in lean months, trees may also be cut for timber or fuel wood. These local threats are currently only considered to be a minor threat. However, in some sites, local livelihood is derived from the smuggling of Red Sanders trees which poses a major threat to the species (Rao and Raju 2002).

Pterocarpus santalinus is also threatened by habitat loss due to anthropogenic pressures on deciduous forests in Andhra Pradesh caused by development activities such as cattle grazing and the farming of cash crops (Mulliken and Crofton 2008). Livestock grazing was identified as a threat in five of the forest divisions where the species was found in the 2018-19 surveys (Ahmedullah *et al.* 2019). The surveys also identified fire as a major threat to the species, with evidence of local fresh fires during the time of the survey (Ahmedullah *et al*. 2019). Fires were also noted as a major threat by Hedge *et al.* (2012) and Ahmedullah *et al.* (2019). Invasive species have also been identified as a threat, these can take the form of other plant species e.g. grasses competing with the species but there is also evidence of the species being affected by pests and diseases (Ahmedullah *et al.* 2019). Very little information is available on the

diseases and pests except some seed-borne diseases caused by *Aspergillus niger*, *A. flavus, Cladosporium ladosporides* and *Fusarium* spp. The species becomes more susceptible to infection if it is has been subject to 'debarking' by smugglers checking for heartwood development; this in effect creates a wound and point of weakness for infections to take hold (Ahmedullah *et al*. 2019).

Conservation Actions **(see Appendix for additional information)**

The species is present in seven *ex situ* collections (BGCI 2020) and numerous plantations. The species is Endangered in India and is protected under law. Original laws prohibiting the harvest of the species were established in the 19th century and they have been developed over the last century. The species has been internationally protected under CITES Appendix II since 1995. Within Andhra Pradesh, it is estimated that 168,000 ha of Red Sanders forest is found within protected areas.

At the national level, several laws are in place to deter the harvest of P*terocarpus santilanus*. This includes the Indian Forest Act and Wildlife Protection Act established in 1927, and amended in 1991 and 2002 (Ahmedullah *et al.* 2019). Export in India has theoretically been banned since 1996 though the EXIM Policy and CITES legislation, with exceptions between 1997 to 2002 and 2002 to 2007 where the trade of legally obtained value added goods was allowed (Ahmedullah *et al.* 2019).

At the state level, Andhra Pradesh introduced their Forest Act in 1967, where *P. santalinus* was listed as a reserved tree; the powers of this law to govern and reduce smuggling were extended in 2016. This clause prevented, felling, sale and transport of *P. santalinus* timber without the correct permits from private forests only (Ahmedullah *et al*. 2019). Andhra Pradesh also established the AP Sandalwood and Red Sanders Wood Transit Rules in 1969 and the AP Red Sanders Wood Possession Rules in 1989. The former law has also been established in Tamil Nadu, and legislation is pending for Karnataka.

In Andhra Pradesh, besides legislative measures, there are also physical deterrents such as the digging of trenches to reduce access to land, strategically placed base camps and armed patrols across 193 sites,113 road checkpoints in the state, one boat party and several strike force units, E-surveillance using infrared cameras in the most vulnerable locations, public engagement and information dissemination, dog squads trained to detect Red Sanders heartwood and a specialist Red Sanders Anti Smuggling Task Force (Ahmedullah *et al*. 2019). All these measures have stopped several criminals and smugglers since 2014, and a noticeable reduction in smuggling has been seen over the last two years (Ahmedullah *et al*. 2019). These efforts are strong but should be maintained, strengthened and extended to cover as much land as possible. Additional resources should also be given to help patrols.

Harvest management plans need to be considered and established for wild trees. However, these will be impossible to implement and in-force until all illegal activity has ceased and there has been the opportunity for recovery (Ahmedullah *et al*. 2019). Sustainable harvest in the wild can only be established through further ecological study. In the mean time, harvest management, rotations, etc., need to be established in plantations, to make them as successful as possible. Export from only cultivated individuals should be considered. Plantations should be established with the seed from propagated/cultivated parental stock only (Ahmedullah *et al.* 2019). Additional management advice and monitoring needs to be imparted to Red Sanders wood farmers to improve cultivation. For export a low quota needs to be set and maintained; the latest NDF study suggests 1,190 MT per year (Ahmedullah *et al.* 2019). There is a need for protection of the forest from fires and cattle grazing, and planting of *P. santalinus* in areas of scarcity, within its native range and where land reclamation is needed (Rao and

Raju, 2002). Some specific recommendations have been made for the conservation and management of the Red Sanders in the recent NDF report (Ahmedullah *et al*. 2019).

Credits

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External Resources

For Supplementary Material, and for Images and External Links to Additional Information, please see the Red List website.

Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
1. Forest -> 1.5. Forest - Subtropical/Tropical Dry	-	Suitable	-

Plant Growth Forms

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Plant Growth Form
TS. Tree - small

Use and Trade

(http://www.iucnredlist.org/technical-documents/classification-schemes)

End Use	Local	National	International
Handicrafts, jewellery, etc.	Yes	Yes	Yes
Fibre	Yes	Yes	No
Food - animal	Yes	No	No
Construction or structural materials	Yes	Yes	Yes
Other household goods	Yes	Yes	Yes
Medicine - human & veterinary	Yes	Yes	No

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
2. Agriculture & aquaculture -> 2.1. Annual & perennial non-timber crops -> 2.1.3. Agro-industry farming	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		
2. Agriculture & aquaculture -> 2.3. Livestock farming & ranching -> 2.3.4. Scale Unknown/Unrecorded	Ongoing	Unknown	Rapid declines	Unknown
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		

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5. Biological resource use -> 5.3. Logging & wood harvesting -> 5.3.2. Intentional use: (large scale) [harvest]	Ongoing	Majority (50-90%)	Rapid declines	Medium impact: 7
	Stresses:	2. Species Stresses -> 2.1. Species mortality 2. Species Stresses -> 2.2. Species disturbance		
7. Natural system modifications -> 7.1. Fire & fire suppression -> 7.1.1. Increase in fire frequency/intensity	Ongoing	Unknown	Slow, significant declines	Unknown
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 2. Species Stresses -> 2.2. Species disturbance		
8. Invasive and other problematic species, genes & diseases -> 8.2. Problematic native species/diseases -> 8.2.2. Named species (Aspergillus niger)	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	2. Species Stresses -> 2.2. Species disturbance		
8. Invasive and other problematic species, genes & diseases -> 8.4. Problematic species/disease of unknown origin -> 8.4.1. Unspecified species	Ongoing	Minority (50%)	Slow, significant declines	Low impact: 5
	Stresses:	2. Species Stresses -> 2.2. Species disturbance		

Conservation Actions in Place

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action in Place
In-place land/water protection
Occurs in at least one protected area: Yes
In-place species management
Subject to ex-situ conservation: Yes
In-place education
Included in international legislation: Yes
Subject to any international management / trade controls: Yes

Conservation Actions Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Action Needed
2. Land/water management -> 2.3. Habitat & natural process restoration
3. Species management -> 3.1. Species management -> 3.1.1. Harvest management
3. Species management -> 3.1. Species management -> 3.1.2. Trade management
3. Species management -> 3.2. Species recovery

Research Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Research Needed
1. Research -> 1.2. Population size, distribution & trends
1. Research -> 1.3. Life history & ecology

Additional Data Fields

Distribution
Estimated area of occupancy (AOO) (km²): 1068
Estimated extent of occurrence (EOO) (km²): 19675
Lower elevation limit (m): 150
Upper elevation limit (m): 900
Population
Continuing decline of mature individuals: Yes
Habitats and Ecology
Continuing decline in area, extent and/or quality of habitat: Yes
Generation Length (years): 100

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The IUCN Red List Partnership

The IUCN Red List of Threatened Species™ is produced and managed by the IUCN Global Species Programme, the IUCN Species Survival Commission (SSC) and The IUCN Red List Partnership.

The IUCN Red List Partners are: Arizona State University; BirdLife International; Botanic Gardens Conservation International; Conservation International; NatureServe; Royal Botanic Gardens, Kew; Sapienza University of Rome; Texas A&M University; and Zoological Society of London.