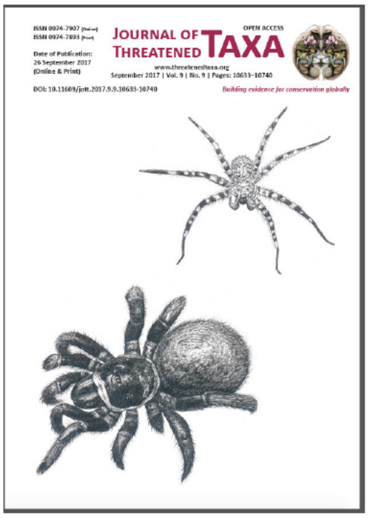

Journal of Threatened Taxa

Building evidence for conservation globally

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Communication

A study on the density, population structure and regeneration of Red Sanders *Pterocarpus santalinus* (Fabales: Fabaceae) in a protected natural habitat - Sri Lankamalleswara Wildlife Sanctuary, Andhra Pradesh, India

Chenchu Ankalaiah, Thondaladinne Mastan & Mullangi Sridhar Reddy

26 September 2017 | Vol. 9| No. 9 | Pp. 10669–10674
10.11609/jott.2869.9.9.10669-10674

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 September 2017 | 9(9): 10669–10674

COMMUNICATION

A study on the density, population structure and regeneration of Red Sanders *Pterocarpus santalinus* (Fabales: Fabaceae) in a protected natural habitat - Sri Lankamalleswara Wildlife Sanctuary, Andhra Pradesh, India

ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

OPEN ACCESS

Chenchu Ankalaiah [1], Thondaladinne Mastan [2] & Mullangi Sridhar Reddy [3]

[1,2,3] Department of Environmental Science, Yogi Vemana University, Kadapa, Andhra Pradesh 516216, India
[3] sridharmullangi@yahoo.com (corresponding author), [2] thndaladinne@gmail.com, [3] sridharmullangi@yahoo.com

Abstract: *Pterocarpus santalinus* is a highly valued medium-sized leguminous endemic tree with a restricted range in the southern Eastern Ghats deciduous forests. The enumeration in four 1ha plots has yielded a total of 878 Red Sanders tree individuals (≥30cm girth at breast height - gbh) with a range of 165–246 individuals per ha and 9–51 individuals per 0.01ha. The size class structure revealed that the majority of individuals occurred in lower gbh classes with 364 individuals (39.5%) in 30–50 cm gbh class and 420 individuals (45.6%) in 51–70 cm gbh class, while in the higher gbh class (71–90 cm gbh) only 129 individuals (14%) and seven individuals in >90cm gbh class were recorded. Overall the population structure indicated a low ratio change in lower gbh classes suggesting a stable population. A higher percentage of life stages in recruitment stage like seedlings and saplings than trees was observed and the feature of re-sprouting from roots after fire damage was also recorded. A bottleneck progress from regenerating trees to adult trees was noticed, may be due to slow growth of the species. High stem density and presence of individuals in all the regenerating and reproductive classes suggest that Red Sanders is tolerant to mild disturbance. But the drastic reduction in the density in higher gbh class reflects the concern for recruitment in future as it may affect the seed output due to loss of reproductively fit mature trees.

Keywords: Coppicing, endemic, multiple stems, population structure, sprouts.

DOI: http://doi.org/10.11609/jott.2869.9.9.10669-10674

Editor: Ravi Prasad Rao, Sri Krishnadevaraya University, Anantapuramu, India. **Date of publication:** 26 September 2017 (online & print)

Manuscript details: Ms # 2869 | Received 08 January 2017 | Final received 30 March 2017 | Finally accepted 02 June 2017

Citation: Ankalaiah, C., T. Mastan & M.S. Reddy (2017). A study on the density, population structure and regeneration of Red Sanders *Pterocarpus santalinus* (Fabales: Fabaceae) in a protected natural habitat - Sri Lankamalleswara Wildlife Sanctuary, Andhra Pradesh, India. *Journal of Threatened Taxa* 9(9): 10669–10674; http://doi.org/10.11609/jott.2869.9.9.10669-10674

Funding: MOEF&CC, New Delhi (14-63-2013 RE).

Competing interests: The authors declare no competing interests.

Author Details and Contribution: Dr. M. Sridhar Reddy is working as Assistant Professor. His interests are forest ecology and forest management. He has contributed to the manuscript in the form of field work and manuscript preparation. C. Ankalaiah is presently working as junior project fellow in MOEF&CC project and he was actively involved in field work and manuscript preparation. T. Mastan is presently working as junior project fellow in UGC project and pursuing PhD work and he has participated equally in field work and as well in manuscript preparation.

Acknowledgements: The financial support by the Ministry of Environment Forests and Climate Change, N.Delhi (MOEF&CC project 14-63-2013-RE) is thankfully acknowledged. The authors thank the Andhra Pradesh Forest Department for giving permission and support to undertake field work in the forest.

INTRODUCTION

Pterocarpus santalinus (Family Faboideae) commonly referred to as Red Sanders is an Endangered tree species endemic to the dry deciduous forests of the southern Eastern Ghats of Andhra Pradesh (CAMP Workshops on Medicinal Plants, India (January 1997) 1998). Its natural habitat is hilly terrains and dry slopes with an altitude range of 300–800 m in Kadapa and Sheshachalam hill ranges (Raju & Nagaraju 1998). Red Sanders is a valuable timber species with multiple uses. A natural dye 'santalin' is extracted from its heartwood which is used as a coloring agent in pharmaceutical preparations, food items, leather and textile industries. The paste/tonic prepared from its wood is used in treating diabetes, skin diseases, fever and to improve eyesight (Jadhav 2008). The timber is high in demand in Japan and China for its exquisite color to prepare luxury furniture, carvings and for its superior acoustic qualities in preparing musical instruments (Mulliken & Crofton 2008). Owing to its high demand, the trees are logged for the heartwood and billets of cleaned heartwood are smuggled from even interior inaccessible forest areas. This kind of exploitation is affecting recruitment, seed output and age structure of the population. The aim of the study is to generate baseline information about the density, regeneration and population structure in terms of girth classes of the Red Sanders tree in relatively less disturbed protected area - Sri Lankamalleswara Wildlife Sanctuary (SLWS) affected by natural fires, browsing and dead wood collection; which will be useful in monitoring and managing the target species in well protected as well as in highly disturbed natural habitat of the target species.

Study area

SLWS covers an area of about 15,135ha in the hill ranges of the southern Eastern Ghats, extending between 14.66–14.73 N & 78.900–78.983 E in Kadapa District of Andhra Pradesh. The sanctuary area comprises dry mixed deciduous forest type with *Pterocarpus santalinus* - *Anogeissus latifolia* - *Hardwickia binata* combination of dominant trees exposed to grazing and annual fires (Champion & Seth 1968). The topography in the forested area comprises valleys and hills in the range of 190–480 m with prominent quartzite outcrops. The soil is red ferruginous loam, shallow and nutrient poor. The temperature is between 13–45 ^{0}C and the region receives around 696cm rainfall, annually.

Field methods and data analysis

The study on the assessment of *Pterocarpus santalinus* population in SLWS is part of a Ministry of Environment, Forests & Climate Change (MoEFCC) project. The field work was undertaken in four study plots of 1ha each namely LKM1 (14.6166 N & 78.9327 E), LKM2 (114.6539 N & 78.9505 E), NPK1 (14.5677 N & 78.9463 E) and NPK2 (14.430 N & 78.9558 E). The field work was carried out from 07 August 2015 to 25 October 2015 with permission from the Andhra Pradesh Forest Department. Each 1ha area comprised 10 10x100 belt transects with at least 50m distance among them and all *Pterocarpus santalinus* tree individuals >30cm girth at 1.3m height (gbh) were enumerated. Along with trees all seedlings (<40 cm height), saplings (40–150 cm height) and regenerating trees (10–30 cm gbh) of *Pterocarpus santalinus* were recorded in the transects (Image 1).

The enumerated trees are categorized into different gbh classes to determine the population structure. Similarly, the population structure of adult trees and regeneration plants was made using the mean frequency values based on the abundance at 0.01 (10x100 scale). SPSS version 20 was used to calculate mean, standard error and to draw bar diagrams. Kolmogorov-Smirnov (K-S) goodness of fit test, contingency table and chi-square test were carried out based on Zar (1999). Linear regression between gbh mid point ln (m_i) and density of individuals in each gbh class ln (N_i+1) was done to determine the recruitment status by analyzing the slope and regression coefficient. Horizontal spread of canopy (D1) and vertical spread from the first joint of the target tree (D2) were added (D1+D2) and a relation with respect to tree height was analysed.

RESULTS

A total of 878 *Pterocarpus santalinus* tree individuals (≥30cm gbh) were recorded in the four 1ha study plots. The range of occurrence is 165–246 individuals per ha and 9–51 individuals per 0.01ha. The size class structure revealed that the majority of individuals are confined to lower gbh classes with 364 individuals (39.5%) in 30–50 cm gbh class and 420 individuals (45.6%) in 51–70 cm gbh class totaling to 784 individuals (85.1%). The higher 71–90 cm gbh class has 129 individuals (14%) and only seven individuals are present in >90cm gbh class (Fig. 2). At 1ha scale the range of occurrence is 33.5–49.6 % in 30–50 cm gbh class, 38.2% to 56.4% in 51–70 cm; 4.6–26.4 % in 71–90 cm and 1.2–2 % in >90cm gbh class. Figure 1 indicates that 30–50 cm is

Image 1. *Pterocarpus santalinus*
a - seedling; b - sapling; c - Red Sanders tree with pods; d - habit.
© Chenchu Ankalaiah & Thondaladinne Mastan

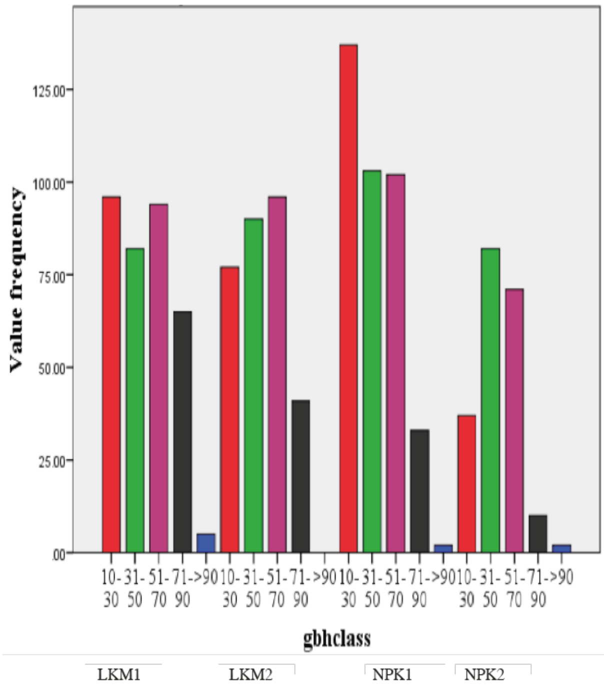

Figure 1. Stem density in increasing girth classes of Red Sanders in four 1ha study areas.

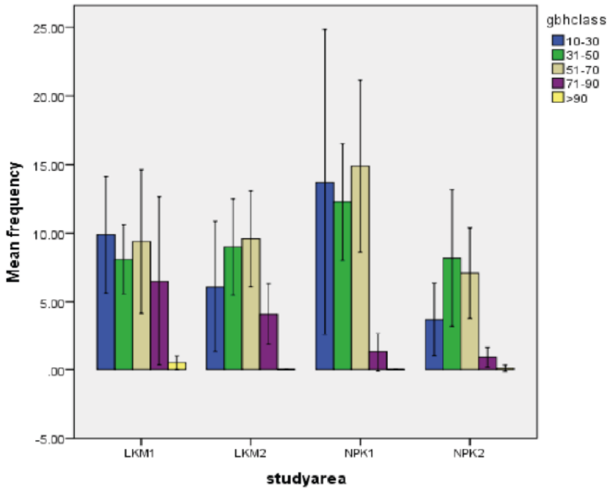

Figure 2. Stem density in different gbh classes with error bars based on abundance at 0.01ha in four 1ha study areas.

the most representative gbh class in NPK1 and NPK2, while in LKM1 and LKM2 the 51–70 cm gbh class has a high number of trees. Site LKM1 has a higher number of trees in 71–90 cm gbh class and as well in >90cm gbh class. Across the four study sites, the mean values of the frequency distribution, showed high variation in larger gbh class 71–90 cm gbh class followed by 51–70 cm and 30–50 cm gbh classes in LKM1 (Fig. 2). In LKM2 site both 30-50cm and 51–70 cm gbh classes showed high variations. In NPK1 site high variation was observed in

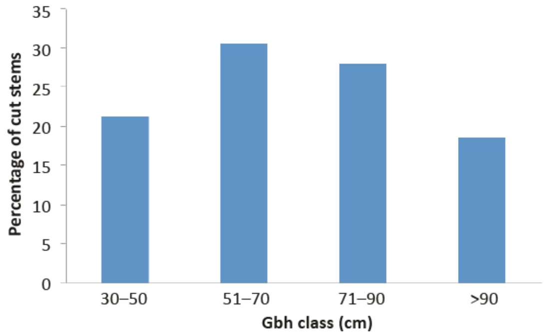

Figure 3. Representation of cut stems of Red Sanders in different gbh classes

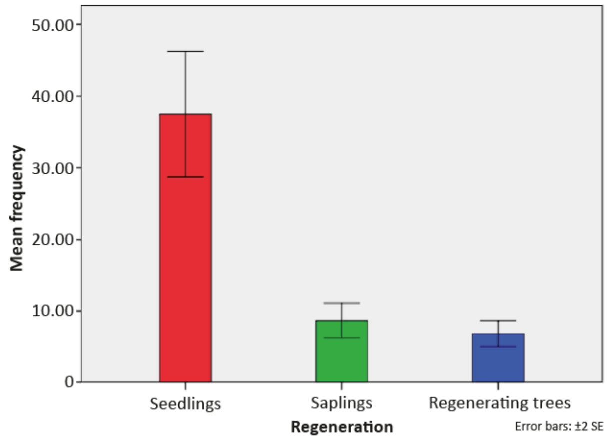

Figure 4. Density of seedlings, saplings and regenerating trees with error bars based on abundance at 0.01ha scale

51–70 cm and contrastingly site NPK2 has high variation in 30–50 cm gbh class. The correlation between gbh midpoints and number of trees in respective gbh classes yielded negative slopes (range of -1.2 to -1.88) and low correlation coefficient (r=0.35 to 0.57) values.

The Kolmogorov-Smirnov test K-S goodness of fit test ($\lambda^2_{3,16,\ 0.05}$ P>0.05) did not yield significant difference indicating that in all the four sites the majority of trees occurred in lower gbh class and within variation of the frequency distribution in different gbh classes is greater than between sites. When the regenerating tree individuals (10-30 cm gbh class) are considered, a range of 37–137 individuals per ha was recorded (Fig. 2). A high density among all the gbh classes and as well as high variation was observed in LKM1 and NPK1 sites, while in the other two sites - LKM2 and NPK2 - a lesser number of regenerating plants than the next higher gbh class (30–50 cm) was observed (Figs. 1 & 2).

Tree Features: multiple stems, cut stems and tree canopy spread.

Multiple stems: The characteristic coppicing ability to produce and survive with multiple stems of Red Sanders in the natural forests was recorded and it has yielded a proportion of 45.4% of trees with at least two stems. The frequency proportion of trees having two stems is high (60.1%) followed by three stems (25%), four stems (8.7%), 14 trees (1.75%) were enumerated with five stems, and seven trees with >5 stems. Across the sites a range of 26.4–59.5 % occurrence of trees with multiple stems was recorded. The contingency table ($\lambda^2_{3,2\ (0.05)}$ P<0.05) indicated a significant difference among the sites in regard to trees with single stems, trees with two stems and trees with >2 stems. The 2x2 Chisquare test ($\lambda^2_{1,1\ (0.05)}$ P<0.05) indicated a significant difference between regenerating trees (10–30 cm gbh) and >30cm trees in possessing single and multiple stems.

A total of 193 cut trees with a range of 15–100 cut stems per ha was recorded in the total 4ha study area. Among them, the most sought gbh class for logging was 51–70 cm (30.6%) followed by 71–90 (28%) and 30–50 cm (21.2%) (Fig. 3). Across the study sites, only two trees with multiple stems were cut and the rest 191 logged trees were with single stems. The average gbh of trees with two stems (range 55.3–59.4 cm) is slightly greater than the trees with >2 stems (range 53.1–59 cm) and also than the trees with single stems (range 46.3–53.8 cm). It indicates that the loggers' choice is trees with single stems. A positive relationship was observed between the variable tree height and the canopy spread among the trees with two stems and trees with >2 stems but not with single stem trees. This indicates that multiple stem trees produce more horizontal spread.

Regeneration

Regeneration progression prevalent in the study sites are seedlings (range 279–369) >saplings (78–99) >regenerating trees (49–77) <adult trees (82–103). This indicates a better advancement from seedlings to saplings than the saplings to regenerating plants and a bottleneck in progression from regenerating tree to adult trees. Among the sites a higher variation is observed in seedlings class than the saplings and regenerating trees (Fig. 4).

DISCUSSION

The results indicate that the Red Sanders tree can be ranked as the dominant tree sharing about 23.5–35 % of the total tree density per ha in these dry forests which comprise 652–747 tree individuals per ha (Mastan et al. 2016) along with co-dominants like *Anogeissus latifolia,* *Chloroxylon swietenia, Terminalia alata*. Differential tolerance levels towards factors like disturbance (Sagar et al. 2003) and seasonal drought conditions (Yadav & Gupta 2006) among trees will dictate their local dominance. The high range of abundance of Red Sanders in these forests at 0.01ha and 1ha scales supports that this species can tolerate and be successful in mild disturbance regimes caused by grazing, dry wood collection, drought conditions and fire as Red Sanders has the ability to produce sprouts from basal and root crowns after disturbance. Similar kind of dominance and regeneration was observed in *Shorea robusta* in Sal forests of Nepal (Sapkota et al. 2009)

The size class population structure did not show typical reverse 'j' shaped curve, which is unique of dry forests (Gonzalez-Rivas et al. 2006) reflecting the presence of selective logging. The low ratio of change from 30–50 cm gbh class to 51–70 cm gbh indicates a stable population and the negative slopes and low values of correlation coefficient among the frequencies in different gbh classes indicate an ongoing recruitment. But the absence and less number of trees in higher gbh class reflects the ongoing uncontrolled logging of mature adult trees. A comparable population structure was observed for *Pterocarpus angolensis*, which is also being harvested unsustainably for timber in Tanzanian dry forests (Schwartz et al. 2002). The most sought gbh class (51–70 cm) for logging indicates that these medium-sized trees are easier to fell with an axe and as well to carry away from the interiors of forest. This kind of exploitation of relatively younger trees and whole range of large sized trees may affect the seed production as only a few trees are found to produce fruits in a season and fruit set is low for this species (Rao & Raju 2002). A drastic reduction of recruitment in forest areas under selective logging was observed in the populations of *Pterocarpus angolensis* in Tanzanian dry forests (Caro et al. 2005). Although this kind of tree harvest creates open canopy areas in dry forests which may trigger the germination and growth of seedling banks, a higher level of seedling mortality reported in dry forests is due to lack of soil moisture and dry conditions in these open gap areas (Khurana & Singh 2001) and germination and early establishment in dry forests is favoured in shaded areas (Vierra & Scariot 2006). According to Shankar (2001) fair regeneration means seedlings>saplings>regenerating trees>adult trees. This kind of presence of higher density of seedlings than saplings and trees in all the four study plots indicates that regeneration of Red Sanders is good. A higher level of re-sprouting from roots after fire was observed during the field work in the forests and this may be the reason for its good representation in the regeneration stages; as also referred by Kennard et al. (2002) about the importance of sprouting and the species-specific difference as a means of survival in the Bolivian dry forests. A similar kind of sprouting from root bases was reported as one of the chief fire response strategies among the native dominant trees in Central African Dry Forests (Otterstrom & Schwartz 2006). The gradual decrease of density of saplings and the restricted movement from 10–30 cm gbh class to the next gbh class of Red Sanders in these forests can be associated with its slow growth and the presence of suffrutex stage as also observed in *Pterocarpus angolensis* regeneration profile in south African dry forests (Shackleton 2002).

CONCLUSION

Red Sanders is well represented in the regenerating class and as well in growth phase gbh classes leading to high stem density in these dry forests suggesting that this species is tolerant to mild disturbance levels. The population structure reveals a decent level of recruitment and the static movement from 30–50 cm gbh class to next gbh classes indicating a stable population. The restricted movement from 10–30 cm gbh to next gbh class suggests the presence of a suffrutex stage and slow growth. Abundance and high range of seedlings manifests the occurrence of re-sprouting from roots after the disturbance of annual fires. Owing to higher number of seedlings and saplings, Red Sanders can be depicted as early successional and shade intolerant tree. The high range of cut stems and trees with multiple stems reflect the site specificity of logging practice. While the low density of trees in higher gbh class and high level of cut stems in 51–70 cm gbh class (reproductively mature trees) due to illegal logging practices may affect the fruit set, recruitment and overall population biology of the species. In light of the growing demand and absence of Red Sanders trees in unprotected forest areas and presence only in lower gbh class in reserve forests, the exploitation of this endemic species in wild life sanctuaries with restricted biotic interferences has to be managed strictly.

REFERENCES

Ahmedullah, M. & M.P. Nayar (1984). Red Sanders tree (*Pterocarpus sanatalinus* L.f.) on the verge of depletion. *Bulletin of the Botanical Survey of India* 26(1–2): 142–143.

CAMP Workshops on Medicinal Plants, India (January 1997) (1998). *Pterocarpus santalinus*. The IUCN Red List of Threatened

Species 1998: e.T32104A9679328. Downloaded on 18 August 2017; http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T32104A9679328.en

Caro, T.M., M. Sungula, M.W. Schwartz & E.T. Bella (2005). Recruitment of *Pterocarpus angolensis* in the wild*. Forest Ecology and Management* 219: 169–175.

Champion, H.G. & S.K. Seth (1968). *A Revised Survey of the Forest Types of India*. Government of India Publications, Delhi, 625pp.

Gonzalez-Rivas, B., M. Tigabu, K. Gerhardt, G. Castro-Marı´n & N.P. Ode´ (2006). Species composition, diversity and local uses of tropical dry deciduous and gallery forests in Nicaragua. *Biodiversity Conservation* 15: 1509–1527.

Jadhav, D. (2008). *Medicinal Plants of India: A Guide to Ayurvedic and Ethnomedicinal Uses of Plants - Vol. 2*. Pawan Kumar Scientific Publishers, Jodhpur India, 417pp.

Kennard, D.K., K. Gould, F.E. Putz, T.S. Fredericksen & F. Morales. (2002). Effect of disturbance intensity on regeneration mechanisms in a tropical dry forest. *Forest Ecology and Management* 162: 197–208.

Khurana, E. & J.S. Singh (2001). Ecology of tree seed and seedlings: Implications for tropical forest conservation and restoration. *Current Science* 80(6): 748–757.

Mulliken, T.T. & P. Crofton (2008). Review of the status, harvest, trade and management of seven Asian CITES-listed medicinal and aromatic plant species. BN Federal Agency for Natural Conservation, 77–92pp.

Otterstram, S.M. & M.W. Schwartz (2006). Responses to fire in selected tropical dry forest trees. *Biotropica* 38(5): 592–598; http://doi.org/10.1111/j.1744-7429.2006.00188.x

Raju, K.K. & A. Nagaraju (1998). Geobotany of Red Sanders (*Pterocarpus santalinus*) - a case study from the southeastern portion of Andhra Pradesh. *Environmental Geology* 37(4): 340–345; http://doi.org/10.1007/s002540050393

Rao, S.P. & A.J.S. Raju (2002). Pollination ecology of the Red Sanders *Pterocarpus santalinus* (Fabaceae), an endemic and endangered tree species. *Current Science* 83(9): 1144–1148.

Sagar, R., A.S. Raghubanshi & J.S. Singh (2003). Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. *Forest Ecology and Management* 186: 61–71.

Sapkota, I.P., M. Tigabu & P. Oden (2009). Species diversity and regeneration of old growth seasonally dry Shorea robusta forests following gap formation. *Journal Forest Research* 20: 7–14.

Schwartz, M.W., T.M. Caro & T. Banda-Sakala (2002). Assessing the sustainability of harvest of *Pterocarpus angolensis* in Rukwa Region, Tanzania. *Forest Ecology and Management* 170(1–3): 259–269; https://doi.org/10.1016/S0378-1127(01)00774-5

Shackleton, C.M. (2002). Growth patterns of *Pterocarpus angolensis* in savannas of the South African lowveld*. Forest Ecology and Management* 166: 85–97.

Shankar, U. (2001). A case of high tree diversity in a Sal (*Shorea robusta*) - dominated lowland forest of eastern Himalaya: floristic composition, regeneration and conservation. *Current Science* 81(7): 776–786.

Vierra, D.L.M. & A. Scariot (2006). Principles of natural regeneration of tropical dry forests for restoration. *Restoration Ecology* 14(1): 11–20.

Yadav, A.S. & S.K. Gupta (2006). Effect of micro-environment and human disturbance on the diversity of woody species in the Sariska Tiger Project in India. *Journal Forest Ecology* 225(1–3): 178–189; http://doi.org/10.1016/j.foreco.2005.12.058

Zar, J.H. (1999). *Biostatistical Analysis - 4th Edition*. Prentice-Hall, Upper Saddle River, New Jersey, 663pp.

Threatened Taxa

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

September 2017 | Vol. 9 | No. 9 | Pages: 10633–10740
Date of Publication: 26 September 2017 (Online & Print)
DOI: 10.11609/jott.2017.9.9.10633-10740
www.threatenedtaxa.org

Articles

Communications

Short Communications

Notes

Response & Reply