

# Sal forest diversity and regeneration pattern in stochastic environment: A review

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## ABSTRACT

The Sal (*Shorea robusta* Gaertn.) forest of North India is currently fast receding due to increasing human interference. The structure and composition of the forest communities has enormous consequences in the conservation and management of forests. The present review aimed to compare the diversity and community attributes to other Sal forests of India. The phytosociological data from different studies were quantitatively compared to work out the species richness, diversity, stand density, size class, plot size and basal area. The area of forest which is more disturbed by anthropogenic activity, the clonal plant species like *Clerodendran*, *Mallotus*, *Holarrhina* were propagated through vegetative reproduction. The forest community which is too stochastic to allow regeneration through seed, a sprouters/ ramet producers may help maintain the minimal herbage cover and considerable plant diversity. The regional forest has considerable plant diversity than that of rest of the sal forest of India.

**Key words:** Diversity, Disturbance, Regeneration, Sal forests, Conservation.

## Introduction

A forest ecosystem is a natural woodland unit consisting of plants, animals and microbes in the area functioning together with all the physical factors of the environment. The world's forest covers approximately 4 billion ha land area, which corresponds to about 31% of total land area. However, forest cover of India has about 690,899 km<sup>2</sup> which constitutes 21.02% of country's geographical area, while sal forest cover approximate 13.3% of total forest area of the country (FSI 2011). Approximately 17,500 species of flowering plants are present in India (Mao *et al.*, 2009). The forest vegetation of Gorakhpur, India is moist deciduous and evergreen type. Here the sal is planted in mostly through *taungya* cultivation (Champion and Seth, 1968). As the Sal ages the species diversity has been at satisfactory level in the

undisturbed conditions but the increasing anthropogenic disturbances from catchment area have caused severe perturbations to the associated communities. Normally the composition of these plantation forests has been found to be quite similar to that of natural growth forests of the region as the Sal trees dominate the overstorey of the natural growth forests as well (Pandey and Shukla, 2001). People living in nearby the sal forest, mainly depend on its resources to satisfy many of their basic needs. They depend on these forests for food, fuel, medicinal herbs, fodder and many other items of their economic use (Shukla and Pandey, 2020).

In India the major causes of diversity loss are habitat destruction, over exploitation of forest resources, deforestation, introduction of alian species and urbanization (UNEP, 2001). Biodiversity of natural ecosystem are under threat due to forest

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fragmentation (Haddad *et al.*, 2015). On a global scale 90% of tropical forest situated outside protected areas (WWF, 2002) and it is experienced with loss of forest cover as well as biodiversity due to biotic disturbances even with protected woodlands (Pandey and Shukla, 2003; Sapkota *et al.*, 2009; Kushwaha and Shankar and Tripathi, 2017; Shukla and Pandey, 2020). This review paper is concerned with the comparison of current diversity-disturbances pattern to the different Sal forests of India and proposes recommendations in order to conserve forest ecosystem for the sustainable use.

### Study area and source of data

The forest of Gorakhpur Division is characterized by even topography, fine alluvial deposits drained by Rapti and Gandak rivers and high water table. Mean altitude of the study area is 95 m at mean sea level. The landscape is frequently intersected by streams and rivulets which run from north-west to south-east direction. Administratively the study area (~10,000 km<sup>2</sup>; 27°05' to 27°40' N latitudes and 83°30' to 84°E longitudes) falls in Gorakhpur district of UP state. Mean annual rainfall is about 1800 mm, most (> 85%) of which is received during monsoon and rest is distributed sporadically from November to May. Relative humidity ranges between 74 - 87%. The mean minimum and mean maximum temperatures during January and June range between 12 - 27 °C and 24 - 39 °C respectively. The soil of Gorakhpur region is classified as Gangetic alluvium, ranging from clayey to sandy loam in texture with pH ranging from 6.5 to 7.5. The natural climax forests of the study area has been classified as Tropical Moist Deciduous and Tropical Semi-evergreen Forests (Champion and Seth, 1968). Most of the plantation forests are dominated by sal (*Shorea robusta*) followed by teak (*Tectona grandis*), *Syzygium heyneanum*, *Terminalia* and *Eucalyptus* species (Pandey and Shukla, 2005).

To compare and assess the present threat to Sal forest in the region, data were obtained through literature review, exploring the relevant online resources, particularly with reference to various field data and research reports, peer-reviewed journals, as well as direct observations in the field.

## Results and Discussion

### Diversity and disturbances

Biological diversity refers to the variety and vari-

ability among living organisms and the ecological complexes in which they found. Biological diversity organized at many levels ranging from complete ecosystems to the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, genus and their relative richness and abundance. Biodiversity is important key aspect for human survival, economic well-being, and maintain ecosystem stability and functioning (Kumar and Saikia, 2020). Diversity of plants at any site is influenced by species distribution and abundance patterns (Majumdar *et al.*, 2012). The species richness of sal forest in this region was quite high (208 species in 24 ha) as compared to those of the Central Himalayas and of central India (Singh and Singh, 1987; Jha and Singh, 1990; Chaturvedi and Raghubanshi, 2014). The total number of tree species was much higher than for the sal forest of the Eastern Himalayas (Uma Shankar 2001). The large tree that exhibits maximum species richness are not dominant in terms of density. This is contrary to other Indian deciduous forests, where the large tree species dominate in numbers.

Sal is one of the dominant tree species in tropical moist and dry deciduous forest in India (Champion and Seth, 1968). Forests of deciduous nature are not considered as species rich but rich in diverse life forms (Gentry, 1995). Deciduous forest occurs in such an area in India where population heavily depends on forest for fuel wood and other economic well-being. Hence, they are most used and threatened ecosystem and is changing into dry deciduous scrub, dry savannah and dry grassland (Sagar and Singh, 2004). The species diversity (H) for the regional sal forest was greater than that for the Eastern Himalayan sal forest (Uma Shankar 2001) and was well within the reported range (0.83–4.1) for the forests of the Indian sub-continent (Jha and Singh, 1990; Pandey and Shukla, 2005; Deka *et al.*, 2012; Kumar and Saikia, 2020). The value of dominance (Cd) in the present study falls within the reported range for other sal forests in India (Pande, 1999; Tripathi and Singh, 2009; Shankar and Tripathi, 2017).

### Regeneration of associated woody plants in sal forest

Seed germination and vegetative propagation are the two major modes of regeneration in perennial plants. A genet is a plant of seed origin while the morphological units in the form of vegetative off-

shoots are called ramets (Pandey, 2000). As in many perennial herbs, a number of woody plants also show continuity of root-stocks in the form of inter-ramet connections which make the genet a physiologically integrated system (Pandey and Shukla, 2019).

Natural regeneration is an essential component for tropical forest ecosystem and is essential for preservation and maintenance of biodiversity (Pandey 2000). Several types of disturbances like logging, trampling, grazing, gap formation, litterfall, fragmentation can affect the potential regenerative status of species composing the forest stand spatially and temporally (Pandey and Shukla, 2001; Sagar and Singh, 2004; Haddad *et al.*, 2015).

The species showing poor sprouting were much greater in number at low disturbance. Conversely, the species showing rich sprouting and ramet formation were much more at high disturbance. The value of diversity index, however, was lower at low disturbance (Shukla and Pandey, 2020). The species like *Clerodendron infortunatum*, *Croton oblongifolius*, *Mallotus philippensis* and *Flacourtia indica* increased their ramet production with increase in disturbance level, but recurrent disturbance of high intensity affected ramet proliferation quite adversely.

### Plant population vs disturbances

Regeneration status of plant species in forest vegetation can be revealed from the population structure (Pandey and Shukla, 2001). It is important to understand the growth behaviour of a species in the ecosystem and is one of the key parameters to determine ecosystem stability (Kadavul and Parthasarathy, 2001). A successful regeneration is indicated by presence of sufficient number of seedlings, saplings and young trees in a given population and the number of seedlings of any species can be considered as the regeneration potential of that species (Pandey and Shukla, 2018).

The regional sal forest was particularly rich owing to a much greater number of perennial herbs, shrubs and lianas. In fact, the number of perennial herbs at the forest core was quite high towards the periphery as compared towards the core of the sanctuary, probably due to a decrease in canopy gaps (Chandrashekhara and Ramakrishnan, 1994). In general, shrubs dominated the understory vegetation. Lianas were more common towards the core of the forest and a few herbaceous climbers were more common in peripheral forest stands. This is in sharp

contrast with the Central Himalayas, where sal undergrowth is herbaceous and grasses predominate (Singh and Singh, 1987). On the other hand, the species richness of the regional sal forest was much lower than that for Barro Colorado Island (Knight 1975).

### Conclusion

Sal forests of Gorakhpur division have been experiencing anthropogenic pressure for five decades. The most serious threat is that a part of the forest has been cleared for Human settlements, Road network and Industrial units. Currently, sal forests are available in the fragmented state and are confined to the protected area network. The remnant patches are not safe despite legal protection. Due to increasing anthropogenic pressure, there may be spatial and temporal threat to the seedling establishment and growth of tree species at the study site. If the present trend of anthropogenic activities continue then the growth, survival and reproductive potential of tree species will be at risk in the near future. Thus, well systematic management plan is required for the conservation of plant vegetation and sustainable use of available plant resources.

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### References

- Champion, H.G. and Seth, S.K. 1968. A revised survey of the forest types of India. Govt. of India, New Delhi.
- Chandrashekhara, U.M. and Ramakrishnan, P.S. 1994. Vegetation and gap dynamics of a tropical wet evergreen forest in the Western Ghats of Kerala, India. *Journal of Tropical Ecology*. 10 : 337–354.
- Chitale V.S, Behera M.D., Matin S., Roy, P.S. and Sinha, V.K. 2013. Characterizing Shorea robusta communities in the part of India terai landscape. *Journal of Forest Research*. 25 : 121-128.
- Chaturvedi, R.K. and Raghubanshi, A.S. 2014. Species

- composition, distribution and diversity of woody species in a Tropical dry forest of India. *Journal of Sustainable Forestry*. 33 : 729-756.
- Deka, J., Tripathi, O.P. and Khan, M.L. 2012. High Dominance of *Shorea robusta* Gaertn. in Alluvial Plain Kamrup Sal Forest of Assam, N. E. India. *International Journal of Ecosystem*. 2 : 67-73.
- FSI 2011. India State of forest report 2011. Forest Survey of India, Ministry of Environment and Forests, Dehra Dun, India.
- Gentry, H. A. 1995. Diversity and floristic composition of neotropical dry forests. pp. 147-192. In: S.H. Bullock, A.M. Harold and E. Medina (eds.) *Seasonally Dry Tropical Forests*. Cambridge University Press, Cambridge.
- Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Song, D.X. and Townshend, J.R. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances*. 20;1(2): e1500052. doi: 10.1126/sciadv.1500052.
- Jha, C.S. and Singh, J.S. 1990. Composition and dynamics of dry tropical forest in relation to soil texture. *Journal of Vegetation Science* 1: 609-614.
- Kadavul, K. and Parthasarathy, N. 2001. Population analysis of *Alphonsea sclerocarpa* Thw. (Annonaceae) in the Kalrayan hills of Eastern Ghats, India. *International Journal of Ecology and Environmental Science*. 27: 51-54.
- Knight, D.H. 1975. A phytosociological analysis of species rich tropical forest on Barro Colorado Island, Panama. *Ecological Monograph*. 45 : 259-289.
- Kumar and Saikia, 2020. Floristic diversity and dominance pattern of Sal (*Shorea robusta*) forests in Ranchi, Jharkhand, eastern India. *Journal of Forestry Research*. 31 : 415- 427.
- Majumdar, K., Uma Shankar and Datta, B. K. 2012. Tree species diversity and stand structure along major community types in lowland primary and secondary moist deciduous forests in Tripura, Northeast India. *Journal of Forestry Research*. 23(4): 553-568.
- Mao, A. A., Hynniewta, T. M. and Sanjappa, M. 2009. Plant wealth of Northeast India with reference to ethnobotany.
- Kushwaha, S. P. S. and Nandy, S. 2012. Species diversity and community structure in sal (*Shorea robusta*) of two different rainfall regimes in West Bengal, India. *Biodiversity and Conservation*. 21: 1215-1228.
- Pande, P.K. 1999. Comparative vegetation analysis and sal (*Shorea robusta*) regeneration in relation to their disturbance magnitude in some sal forests. *Tropical Ecology*. 40 : 51-61.
- Pandey, S.K. 2000. *Population status and regeneration strategy of some perennial legumes in plantation forest of north-eastern Uttar Pradesh*. Ph.D. Thesis, Department of Botany, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, India. 263 pages.
- Pandey, S.K. and Shukla, R.P. 2001. Regeneration strategy and plant diversity status in degraded sal forests. *Current Science*. 81 : 95-102.
- Pandey, S. K. and Shukla, R. P. 2003. Plant diversity in managed sal (*Shorea robusta* Gaertn.) forests of Gorakhpur, India: species composition, regeneration and conservation. *Biodiversity and Conservation*. 12: 2295-2319.
- Pandey, S.K. and Shukla, R.P. 2005. Plant community and diversity patterns within the forested land scape of north-western U.P. *India Forester*. 131 : 1217-1226.
- Pandey, S.K. and Shukla, R.P. 2018. Plant population structure and species diversity status at two disturbance regimes within mixed forests and sal forests of Gorakhpur, India. *International Journal of Ecology and Environmental Sciences*. 44 : 43-58.
- Pandey, S.K. and Shukla, R.P. 2019. Effect of disturbance on population structure, regeneration and conservation of *Moghania chappar* in sal forests of Gorakhpur, India. *Tropical Ecology*. 60 : 337-349.
- Shukla, R.P. and Pandey, S.K. 2020. *Vegetation and Plant Diversity*. Pp 232 SSPH, New Delhi.
- Sagar, R. and Singh, J.S. 2004. Local plant species depletion in a tropical dry deciduous forest of northern India. *Environmental Conservation*. 31(1) : 55-62.
- Sapkota, I.P., Tigabu, M. and Odén, P.C. 2009. Species diversity and regeneration of old-growth seasonally dry *Shorea robusta* forests following gap formation. *Journal of Forestry Research*. 20 : 7-14.
- Shankar, U. and Tripathi, A. K. 2017. Rainforests north of the Tropic of Cancer: Physiognomy, floristics and diversity in 'lowland rainforests' of Meghalaya, India. *Plant diversity*, 39: 20- 36.
- Singh J.S. and Singh S.P. 1987. Forest vegetation of the Himalaya. *Botanical Review*. 53 : 80-92.
- Tripathi, K. P. and Singh, B. 2009. Species diversity and vegetation structure across various strata in natural and plantation forests in Kateraniaghat Wildlife Sanctuary, North India. *Tropical Ecology*. 50: 191-200.
- Uma Shankar, 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: 776-786.
- UNEP. 2001. India: State of the Environment - 2001. United Nations Environment Programme.
- WWF. 2002. Forest management outside protected areas. World Wildlife Fund (WWF), Gland, Switzerland.
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