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SPECIES DISTRIBUTION MODELLING OF *BRUCEA MOLLIS* WALL. EX KURZ IN NORTHEAST INDIA FOR ITS CONSERVATION

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Abstract

Brucea mollis Wall. ex Kurz. (Simaroubaceae), an endangered and economically important medicinal plant species distributed in north-eastern India. Its population is facing continuous decline over past decades due to various anthropogenic pressure including deforestation, forest fragmentation, shifting cultivation and agricultural expansion. Predicting the potential habitat may help in identifying suitable habitats for rehabilitation or reintroduction and will support in improving their population status. The present study was aimed to model the distribution of potential habitats of *B. mollis* in north-eastern region and to identify the significant factors affecting the distribution of potential habitats using Species Distribution Modelling (SDM). The potential habitat distribution map was generated using ArcMap by dividing the probability range into five classes, *i.e.*, very high, high, moderate, low and very low. The result showed that only 1% (1058 km^2) of the total geographical area of study area falls under high potential zone of habitation whereas 2% falls under high potential zone, 3% under moderate potential zone, 6% for low and 88% fall under very low potential for habitat suitability of *B. mollis*. The present study was emphasized with the specific objectives to study the distribution, population survey, identifying areas for conservation and reintroduction of *B. mollis*, thereby improving its population status.

Key words : *Brucea mollis*, Conservation, Habitat suitability, Northeast India, Threatened species.

Introduction

In India, the genus *Brucea* is represented by two species *viz. Brucea javanica* (L.) Merr. and *Brucea mollis* Wall. ex Kurz. (Gupta *et al*., 2004; Santapau and Henery, 1973). *Brucea mollis* belongs to the family Simaroubaceae and is an endangered potential medicinal plant of Northeast India as listed by Conservation Assessment and Management Plan (CAMP), Foundation for Revitalization of Local Health Tradition (FRLHT), Bangalore (Kakati and Borthakur, 2016). The species was reported to occur in Arunachal Pradesh, Assam, Darjeeling, Manipur, Meghalaya, Nagaland, and Sikkim, of North-East India (Gupta *et al*., 2004). It is also reported from Bhutan, Cambodia, China, Laos, Malaysia, Myanmar, Nepal, Philippine, Thailand and Vietnam (Pullaiah, 2006). *B. mollis* have immense medicinal properties in traditional medicines (Bharati and Singh, 2012). During recent decades due to several anthropogenic activities *viz*., over-exploitation, habitat destruction, and fragmentation of forest areas have substantially altered the natural landscapes affecting the distribution of species populations and habitats (Hansen *et al*., 2013), which simultaneously hinder the sufficient propagation of the plant in its natural condition (Borthakur *et al*., 2018). Moreover, the indigenous flora of region today is mostly confined to the native forests found in the protected areas such as National Parks, Biosphere Reserves, Wildlife Sanctuaries, etc. Even these protected areas are under tremendous anthropogenic pressure, and several floristic elements face threat of extinction. So, considering the increased threats from large-scale deforestation and degradation of natural habitat, it is essential to develop some appropriate management strategies and effective plans for conservation of these floristic elements (Ronghang *et al*., 2012).

Geographic information system (GIS) can be used as a useful tool for conservation of threatened plant species through the identification of their habitats, and classifying the habitats for conservation prioritization (Brummitt *et al*., 2008). Since species with narrow

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distribution range are more prone to extinction (Baillie *et al*., 2004; Isik, 2011), geographical analysis can be used to assess the conservation status of a species by identifying the extent of species distribution (Willis *et al*., 2003). GIS layers containing the information on human interventions such as roads, agricultural conversion etc. can be overlaid on the species distribution map to identify the threats and conservation status of plant species (Willemen *et al*., 2007; Maxted *et al*., 2008) and ecosystems (Jarvis *et al*., 2010). A GIS-based analysis would also attempt to identify the factors causing depletion to the populations of the threatened species. Species reintroduction through GIS-based analysis is one of the successful ecological techniques for restoration of the depleted species population (Martinez-Meyer *et al*., 2006; Nazeri *et al*., 2010; Polak and Saltz, 2011). Species reintroduction needs detailed knowledge on the distribution factors of the species potential habitats to rehabilitate the threatened species in a terrestrial ecosystem (Adhikari *et al*., 2012). One of such successful technology of species reintroduction for threatened species is Species Distribution Modelling (SDM). The technique of SDM has been successfully used in restoring the critical habitats of many threatened species worldwide, along with predicting climate change on species and ecosystems (Brooks *et al*., 2004; Samways, 2005; Giriraj *et al*., 2008; Franklin, 2009; Barik and Adhikari, 2011). Many important species such as *Vanilla borneensis* Rolfe, *Elaeocarpus serratus* L., *Ilex khasiana* Purk., *Adinandra griffithii* Dyer, *Calamus nambariensis* Becc. from North-eastern part of India have been map to predict the habitat potential for reintroduction using such technology (Deka *et al*., 2017; Baruah *et al*., 2019; Adhikari *et al*., 2012; Adhikari *et al*., 2018; Borthakur *et al*., 2018; Deka *et al*., 2017). SDM is a useful technique to depict the current as well as the future geographical distribution of species based on their ecological niche and helps to construct a predictive distributional map (Baruah *et al*., 2019). Thus, such modelling technique can help to identify the areas for species reserves, reintroduction, and in developing effective species conservation measures (Deka *et al*., 2017). The present study was aimed to model the distribution of potential habitats of *B. mollis* in the north-eastern region of India and to identify the suitable habitat for its reintroduction and the major factors determining the distribution of the potential habitats.

Materials and Methods

Species Distribution Modelling

Study area and species occurrence data

The model was calibrated from most of the north-eastern region including Assam (*Karbi* Anglong and North Cachar Hills), Meghalaya (Jaintia hills), Nagaland (Naga Hills) and Arunachal Pradesh (Dafla Hill range). Primary distributional records of the species were collected from East *Karbi* Anglong wildlife sanctuary, *Karbi* Anglong district of Assam, India. The coordinates of all the occurrence points of *B. mollis* were recorded to an accuracy of 10–40 m using a GPS (Garmin). The coordinates were then converted to decimal degrees for use in modelling the distribution of potential habitats of the species in its native range.

Environmental data

Fifteen environmental variables *viz.*, Physiologically Equivalent Temperature (PET), wettest quarter, climatic moisture index, topographic wetness index, minimum temperature, warmest, PET seasonality, continentality, acidic index thorn thwaite, topographic roughness index, PET warmest quarter, PET driest quarter, PET coldest quarter, Thermicity index, annual PET, Max. temp. coldest and Emberger Q. All the environmental data was converted to ASCII raster format with a resolution of 800 × 800 m for use in Maxent modelling.

Analysis of variable contributed

The estimates of relative contributions of environmental variables to the Maxent model to determine the first estimate, in each iteration of training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable, in turn, the values of that variable on training presence and background data are randomly permuted. The model is evaluated on permuted data, and the resulting drop in training AUC is shown in table 1, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Model calibration and evaluation

We used Maxent Version 3.3.3e (Phillips *et al*., 2006) to model the distribution of potential habitats in the study site. The model was parameterized using the default parameters pertaining to the number of background points (10,000), regularization multiplier (1), the maximum number of iterations (500), convergence threshold (0.00001), and default prevalence (0.5). Auto-feature option was selected for model fitting. The number of replication was set to 10, and cross-validation option was selected for the replicated run type. We selected the jackknifing option to measure the variable contribution.

'Cloglog' output format was chosen for the visualization of the model results. Model fitness test performance was estimated based on the traditional receiver operating characteristic (ROC) curve and area under curve (AUC) metric (Phillips *et al*., 2006). The model classification was done following the conservative guide by Thuiller *et al*., (2005), *i.e.* random (AUC <0.8), fair (0.8 < AUC < 0.9), good (0.9 < AUC < 0.95), and very good (0.95 < AUC < 1.0).

Identification and characterization of potential habitats

The possible habitat distribution map was generated using ArcMap by dividing the probability range into five classes, *i.e.* very high, high, moderate, low, and very low. Considering the prepared map, field surveys were undertaken during 2016 to July 2017 in search of new populations and for ground verification of predicted potential habitats. Habitat characterization was done based on topographic, forest/vegetation type and tree canopy cover. Slope orientation and elevation were ascertained using a GPS device (Garmin e-trex), and the slope angle was estimated using a clinometer. Vegetation type was determined following the classification of Champion and Seth (1968).

Results and Discussion

Evaluation of model performance

Tests of model performance generated optimal results for ROC full (mean AUC 0.99) and ROC partial (mean AUC 0.98). The distribution of AUC ratios, calculated from bootstrap values as AUC partial/AUC random, was significantly higher than random expectations showing very good model consistency (Fig. 1).

Analysis of variable contributed

Jackknifing of regularized training gain and the analysis of variable for *B. mollis* revealed that the environmental variable with the highest gain, when used in isolation, is climatic Moisture Index (Fig. 2). The environmental variable that decreases the gain the most when it is omitted is climatic Moisture Index, which therefore appears to have the most information that isn't present in the other variables to the Max Ent model.

Potential habitat distribution and characterization

The Maxent model showed that 1% of studied area is under very high suitable zone (1058 km^2) followed by 2% under high suitable zone (1288 km^2), 3% under moderate suitable zone (2131 km^2), 6% under low suitable zone (5064 km^2) and 88% under very low suitable zone (72355 km^2) (Fig. 3).

Assessment of habitat status and identiûcation of areas for reintroduction

After superimposing the predicted potential habitat map of *B. mollis* on Google Earth satellite images revealed a mosaic of habitats to be suitable for the species persistence (Fig. 4). The areas with high to very high habitat suitability for the species were mostly located under moist semi-evergreen forests types. The areas with medium to low habitat suitability were degraded forest areas, farming areas, farm gardens and human settlements. The areas with very low habitat suitability were grasslands, degraded forests and human settlements.

Population and regeneration status

We inventoried 268 individuals of *B. mollis*, comprising of 50 seedlings, 89 saplings and 129 adults from the study area. The most significant number of adult trees was recorded from Langlokso with 17 individuals followed by Langpratlangso, Langtuk hanse and Noralangso with ≥15 individuals each table 2.

Factors determining the distribution of B. mollis potential habitat

In the present study, remotely sensed environmental data, climatic Moisture Index effectively discriminated the suitable and unsuitable habitats of *B. mollis*. Even the environmental variable that decreases the gain the most when it is omitted is climatic Moisture Index, which therefore appears to have the most information that isn't present in the other variables. Model output and field observation revealed that the suitable natural habitats of

Table 1: Estimates of relative contributions and permutation importance of the predictor environmental variables to the MaxEnt model.

Variable	Percent contribution	Permutation importance
PET Wettest Quarter	25.6	0.4
Climatic Moisture Index	22.4	60.6
Topographic Wetness Index	15.3	7.2
Min. Temp. Warmest	14.3	4.5
PET seasonality	6.5	2
Continentality	5.3	20.3
Aridity Index Thornthwaite	4.2	0.1
Topographic Roughness Index	3	0.8
PET Warmest Quarter	1.9	2.4
PET Driest Quarter	1	1.5
PET Coldest Quarter	0.5	0.1
Thermicity Index	0	0
Annual PET	0	0
Max. Temp. Coldest	0	0
embergerQ	0	0

Table 2: Species abundance in the occurrence localities.

Occurrence localities	Altitude	Forest type (m)	Abundance (No. of individuals)			
			Adults	Sapling	Seedling	Total
Borpung	340	Moist semi-evergreen	10	15	7	32
Tarapung	300	Moist semi-evergreen	12	17	11	40
Noralangso	344	Moist semi-evergreen	15	10	9	34
Phanglangso	440	Moist semi-evergreen	11	7	3	21
Langtuk hanse	456	Moist semi-evergreen	15	9	7	31
Langpratlangso	540	Moist semi-evergreen	16	14	8	38
Kanduwa bosti	458	Moist semi-evergreen	10	5	3	18
Langlokso	345	Moist semi-evergreen	17	5	2	24
Samelangso	320	Moist semi-evergreen	8	4	0	12
Dengaon	330	Moist semi-evergreen	5	0	0	5
Dentaghat	300	Moist semi-evergreen	10	3	0	13
Total			129	89	50	268

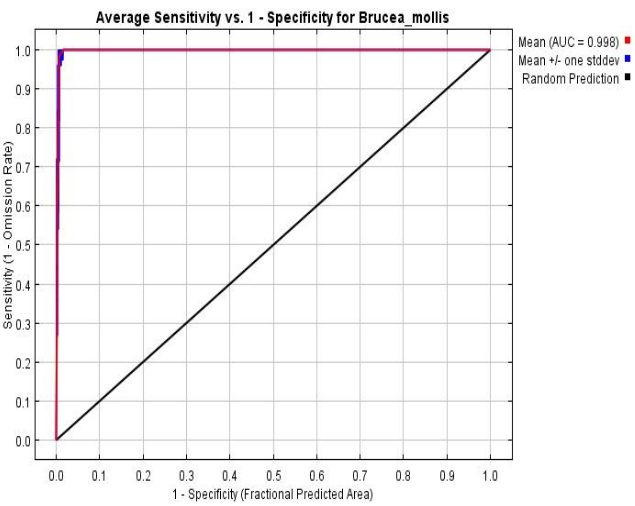

Fig. 1: Result of model evaluation tests done using full and partial ROC-AUC measures.

the species are distributed moistly under moist semi-evergreen forest types of the region. The primary threat to *B. mollis* is human disturbances, as evident by various anthropogenic pressure such as deforestation, forest fragmentation, shifting cultivation and agricultural expansion, which result into continuous decline in its population in natural habitat. The *Karbi* Anglong district of Assam has been identified to offer high suitable environmental conditions for the reintroduction of this species (Borthakur *et al*., 2018). Our study reveals that large areas for reintroduction of *B. mollis* in most parts of north-eastern region make it broader in conservation perspective. The earlier study on *B. mollis* was conducted by Borthakur *et al*., (2018), considering only two environmental variables *viz.*, Normalized diûerence vegetation index (NDVI) and elevation and our study was conducted using fifteen environmental variables, which make the approach different from the earlier one. Due to change in number of environmental variables in our study, there were slight changes in the potential habitat distribution map of *B. mollis*. The potential habitat distribution map generated by both the studies have some variation especially in Meghalaya, Manipur and towards the upper Assam regions. The variation on such generated map can be minimized by using the consensus areas from both the generated maps. The consensus area from both the potential habitat distribution maps could be highly suitable for the growth and further reintroduction of *B. mollis*. The changes in the potential habitat distribution map of any species is due to changes in environmental variables and it could be the significant factors, which affects the distribution potential of that species. Further detailed studies on those important environmental variables are needed, focusing on the particular ecological niche of the species.

Conservation aspects

The highly suitable habitats of the species within the study area, is already under threat due to various anthropogenic activities such as road construction, shifting cultivation, mining, and grazing, which eventually making the forest cover of these areas to experience a tremendous change in the last few decades. The population of such threatened species needs to protect strictly and monitored within its natural habitat. Illegal timber extraction, shifting cultivation, forest fires, and illicit agricultural expansion, need to be check in and around the population of this species (Mir *et al*., 2017). Various anthropogenic pressures on the species can be minimized by creating awareness among the local people and encouraging them to grow the species and to practice as agroforestry in those areas, which have been identified as the high suitable areas for its growth. More importantly, the species need to be brought under in-situ conservation programs by superimposing the predicted potential habitat distribution map on Google Earth images identiûed forest areas and could be used for reintroduction of the species in the wild.

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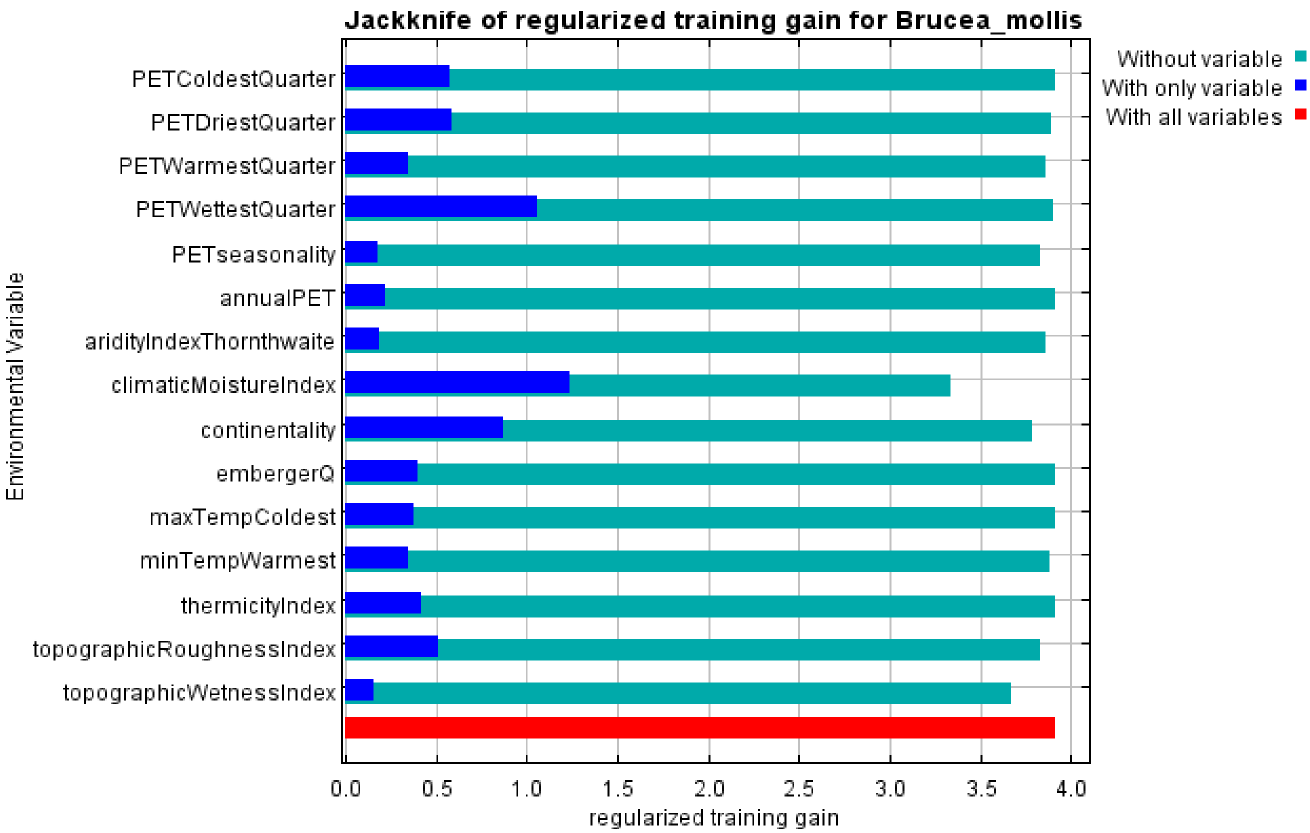

Fig. 2: Jackknife of regularized training gain for *B. mollis*.

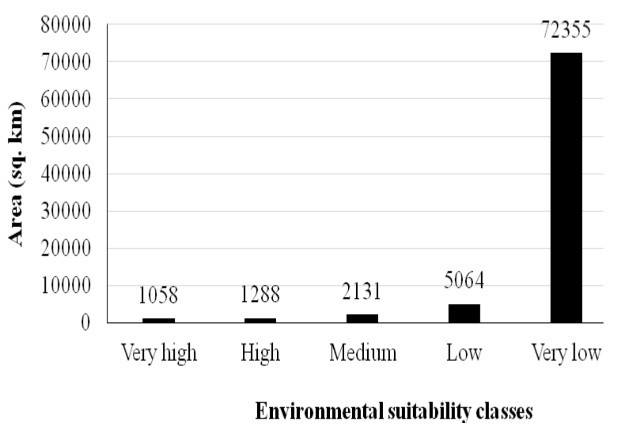

Fig. 3: Area under different environmental suitability classes in the identified area of interest of *B. mollis*.

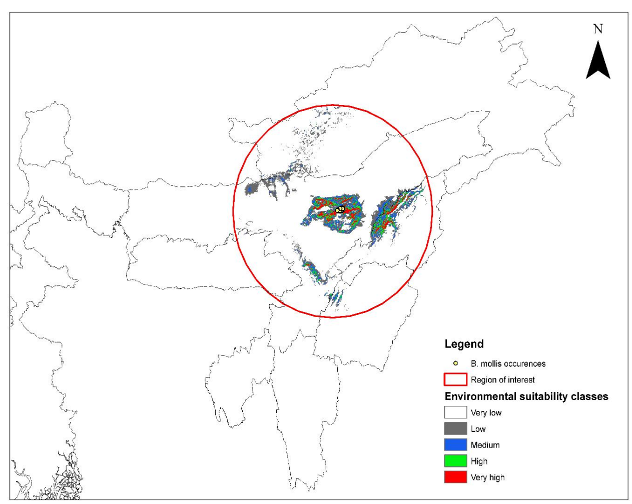

Fig. 4: Distribution of potential habitats of *B. mollis* in northeast India.

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References

Adhikari, D., S.K. Barik and K. Upadhaya (2012). Habitat distribution modelling for reintroduction of *Ilex khasiana* Purk.: a critically endangered tree species of northeastern India. *Ecol. Eng.*, **40:** 37-43.

Adhikari, D., A.H. Mir, K. Upadhaya, V. Iralu and D.K. Roy (2018). Abundance and habitat-suitability relationship deteriorate in fragmented forest landscapes: a case of *Adinandra griffithii* Dyer, a threatened endemic tree from Meghalaya in northeast India, *Ecological Processes*, **7:**3.

Baillie, J.E.M., C. Hilton-Taylor and S.N. Stuart (2004). *IUCN Red List of Threatened Species. A Global Species Assessment*. Publishers name? Switzerland and Cambridge, UK.

Barik, S.K. and D. Adhikari (2011). Predicting geographic distribution of an invasive species *Chromolaena odorata* L (King) & H.E. Robins in Indian subcontinent under climate change scenarios. In: J.R. Bhatt, J.S. Singh, R.S. Tripathi, S.P. Singh and R.K. Kohli (Eds.), Invasive Alien Plants-An Ecological Appraisal for the Indian Subcontinent. CABI, Oxfordshire, UK.

Baruah, P.S., K. Deka, L. Lahkar, B. Sarma, S.K. Borthakur and B. Tanti (2019). Habitat distribution modelling and reinforcement of *Elaeocarpus serratus* L. - A threatened tree species of Assam, India for improvement of its conservation status. *Acta Ecologica Sinica*, **39(1):** 42-49.

Bharati, K.A. and H.B. Singh (2012). *Brucea mollis* Wall. ex Kurz.: Untapped potential medicinal plant of Northeast India. *NeBIO*, **3:** 26-28.

Borthakur, S.K., P.S. Baruah, K. Deka, P. Das, B. Sarma, D. Adhikari and B. Tanti (2018). Habitat distribution modelling for improving conservation status of *Brucea mollis* Wall. ex Kurz.– An endangered potential medicinal plant of Northeast India. *Journal for Nature Conservation*, **42:** 104-110.

Brooks, T.M., G.A.B. Da Fonseca and A.S.L. Rodrigues (2004). Protected areas and species. *Conserv. Biol*., **18:** 616.

Brummitt, N., S. Bachman and J. Moat (2008). Applications of the IUCN Red List: Towards a global barometer for plant diversity. *Endangered Species Research*, **6:** 127-135.

Deka, K., P.S. Baruah, B. Sarma, S.K. Borthakur and B. Tanti (2017). Preventing extinction and improving conservation status of *Vanilla borneensis* Rolfe-A rare, endemic and threatened orchid of Assam, India. *Journal for Nature Conservation*, **37:** 39-46.

Deka, K., S.K. Borthakur and B. Tanti (2017). Distribution and population dynamics of *Calamus nambariensis* Becc.– An endemic and threatened cane of Assam. *Annals of Plant Sciences*, **6(12):** 1829-1834.

Franklin, J. (2009). Mapping Species Distributions: Spatial Inference and Prediction. Cambridge University Press, 338.

Giriraj, A., M. Irfan-Ullah, B.R. Ramesh, P.V. Karunakaran, A. Jentsch and M.S.R. Murthy (2008). Mapping the potential distribution Of *Rhododendron arboretum* Sm. Ssp nilagiricum (Zenker) Tagg (Ericaceae), an endemic plant using Ecological niche modeling. *Curr. Sci*., **94:** 1605-1612.

Gupta, A.K., M. Sharma and N. Tandon (2004). Reviews on Indian Medicinal Plants. Indian Council of Medical Research, New Delhi, pp. 431-433.

Hansen, M.C., P.V. Potapov, R. Moore, M. Hancher, S.A. Turubanova, A.L. Tyukavina, C.O. Justice and J.R.G. Townshend (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, **342(6160):** 850-853.

Isik, K. (2011). Rare and endemic species: Why are they prone to extinction? *Turkish Journal of Botany*, **35:** 411-417.

Jarvis, A., J.L. Touval, M.C. Schmitz, L. Sotomayo and G.G. Hyman (2010). Assessment of threats to ecosystems in South America. *Journal for Nature Conservation*, **18:** 180-188.

Kakati, D. and S. Borthakur (2016). Morphological and anatomical studies of vegetative parts of *Brucea mollis* Wall. ex Kurz -an endemic medicinal plant of Assam. *NeBIO,* **7:** 57-65.

Martinez-Meyer, E., A.T. Peterson, J.I. Servin and L.F. Kiff (2006). Ecological niche modelling and prioritizing areas for species reintroductions. *Journal for Nature Conservation*, **40:** 411-418.

Maxted, N., J.M. Iriondo, B.V. Ford-Lloyd, M.E. Dulloo, S.P. Kell and J. Turok (2008). Crop Wild Relatives Conservation and Use. Centre for Agriculture and Bioscience, London, UK.

Mir, A.H., K. Upadhaya, N. Odyuo and B.K. Tiwari (2017). Rediscovery of *Magnolia rabaniana* (Magnoliaceae): A threatened tree species of Meghalaya, northeast India. *Journal of Asia-Paciûc Biodiversity*, **10:** 127-131.

Nazeri, M., K. Jusoff, A.R. Bahaman and N. Madani (2010). Modelling the potential distribution of wildlife species in the tropics. *World Journal of Zoology*, **5:** 225-231.

Phillips, S.J., R.P. Anderson and R.E. Schapire (2006). Maximum entropy modelling of species geographic distributions. *Ecol Model*, **190(3):** 231-259.

Polak, T. and D. Saltz (2011). Reintroduction as an ecosystem restoration technique. *Conservation Biology*, **25:** 424-427.

Pullaiah, T. (2006). Encyclopaedia of World Medicinal Plants. Vol 1. Regency Publications, New Delhi, pp. 360.

Ronghang, R., R. Teron, A.K. Tamuli and C.R. Rajkhowa (2012). Tribal societies and deforestation in *Karbi* Anglong District of Assam (India). *The Ecoscan*, **1:** 231-236.

Samways, M.J. 2005. Insect Diversity Conservation. Cambridge University Press, Cambridge.

Santapau, H. and A.N. Henery (1973). A dictionary of the flowering plants in India. CSIR, New Delhi, pp. 27.

Thuiller, W., S. Lavorel, M.B. Araújo, M.T. Sykes and I.C. Prentice (2005). Climate change threats to plant diversity in Europe. Proc Natl Acad Sci USA, **102(23):** 8245-8250.

Willemen, L., X. Scheldeman, V. Soto Cabellos, S. Rafael Salazar and L. Guarino (2007). Spatial patterns of diversity and genetic erosion of traditional cassava (Manihot esculenta Crantz.) in the Peruvian Amazon: An evaluation of socio-economic and environmental indicators. *Genetic Resources and Crop Evolution*, **54:** 1599-1612.

Willis, F., J. Moat and A. Paton (2003). Defining a role for herbarium data in Red List assessments: a case study of Plectranthus from Eastern and Southern tropical Africa. *Biodiversity and Conservation*, **12:** 1537-1552.