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Predicting habitat suitability of critically endangered *Nepenthes sumatrana*

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Abstract. *Nepenthes sumatrana* is a tropical pitcher plant endemic to Sumatra. It has been categorised as critically endangered based on the IUCN Red List. It often occupies in lowland tropical forest of Sumatra. Its habitat has been threatened by land use conversion in the recent decade. Due to the high threats in the wild, the conservation efforts are necessarily required. It is not possible to assess all locations that are suitable for this species. In terms of addressing that issue, Species Distribution Modelling is considered as an alternative way to identify the regions that have the similar environmental conditions to where the species is known to occur. The occurrence records were derived from Global Biodiversity Information Facility and reliable scientific papers. Topography, soil, climate and land cover were used as predictors of the model. MaxEnt algorithm was used to predict the habitat suitability. MaxEnt produces a predictive model with the AUC value of 0.833 indicating that the model has a good performance. The suitable habitats are predicted in several different locations in Sumatra. The information about predicted suitability habitat would be useful to prioritize the protected areas of this species. Furthermore, our findings would be valuable for the discovery of unknown subpopulation.

Keywords: Habitat suitability, Maximum Entropy, *Nepenthes sumatrana*, Sumatra

1. Introduction

Nepenthes sumatrana is a critically endangered tropical pitcher plant endemic to Sumatra [1]. It is found in North Sumatra and West Sumatra, but the geographical extent of this species remains uncertain [1]. It may be found in other regions in Sumatra. According to the previous study, this species prefers to occupy undisturbed lowland forest with sandstone substrate [2]. A moist and shade area is the suitable habitat for this species and it is rarely found in open clearing areas [2]. It is often seen in the steep hills with elevation from 0 to 800 m above sea level. Forest clearing for agriculture and plantations causes this species to be vulnerable to extinction in the wild [2].

According to the IUCN Red List, the conservation status of this species is categorised as critically endangered [3]. Its population tends to decrease with the total mature individuals around 5,000 [3]. At the first record, it was only found in a restricted area in Sumatra [2]. However, several recent studies stated that this species also occurred at different locations in Sumatra [4-6]. It indicates other regions in Sumatra may be potentially speculated as the suitable habitats of this species. In fact, it is not possible to survey all locations in Sumatra to collect the occurrence records of this species. Habitat modelling approach can be considered as an alternative way to predict the suitable habitat of this species.



Species Distribution modelling has been increasing in use for many ecological applications [7, 8]. It has been widely used to predict the rare plants [9, 10] and invasive plant species [11, 12]. There are many varieties of algorithms that are widely used for predicting the suitable habitat for a certain species [13, 14]. These models incorporate the relationship between occurrence records and biophysical environments variables [7, 15]. However, not all model predictions are applicable for predicting rare and endangered species in which only few occurrence records are available [16, 17]. Maximum Entropy (MaxEnt) is one of model predictions that well performed [7, 18] and effective for predicting a species with small sample size [16, 19]. In recent study, MaxEnt outperformed in predicting the distribution of *Guettarda speciosa* [20]. Some previous studies have uncovered ecological aspects of this species, but the comprehensive spatial distribution has not been yet conducted throughout landscape of Sumatra. This study aims to identify the geographically suitable habitat of critically endangered *N. sumatrana* across the mainland of Sumatra. The habitat characteristics where the species found will be extrapolated to other geographic regions in Sumatra.

2. Materials and methods

Occurrence records were derived from three reliable scientific journals that stated the occurrence of this species in Sumatra [4, 5, 6] and Global Biodiversity Information Facility [21]. Topography (elevation, slope), soil aspects (soil organic carbon, soil pH, carbon exchange capacity), Climate (annual mean temperature, annual precipitation, precipitation of driest month, precipitation of wettest month), and land cover variables were used as predictors of the model. The Digital Elevation Model (DEM) with resolution 30 seconds (1 km²) was derived from the Shuttle Radar Topography Mission (SRTM) [22, 23]. Slope was analysed from DEM Data. Annual mean temperature, annual precipitation, precipitation of driest month and precipitation of wettest month were extracted from worldclim global data. These variables were the average for the years 1970-2000 with the spatial resolution 30 seconds (1 km²) [24]. The soil variables were available at a spatial resolution of 250 meters [25]. Land Cover data was derived from Moderate Resolution Imaging Spectroradiometer (MODIS) Land Cover Type (MCD12Q1) Version 6 [26].

Maximum Entropy (MaxEnt) software version 3.4.4 was used to model habitat suitability of critically endangered *N. sumatrana* by implementing a machine learning technique called Maximum Entropy [27]. The performance of the model was evaluated using several methods. Area under the receiver operating curve (AUC) was used to evaluate the model performance [7, 28]. A jackknife procedure was used to test variable importance [29]. The resulted suitability habitat map was overlaid with conservation areas to identify the suitable habitats of this species inside conservation areas [30].

3. Results

The predictive map of habitat suitability is the output of MaxEnt model. The colours of the image indicates the predicted suitable conditions for this species. A red colour indicating high probability of suitable conditions for this species, yellow to green indicates the intermediate probability this species may be found, lighter blue indicating the low predicted suitable conditions (figure 1). High suitable habitats for this species are predicted in West Sumatra, North Sumatra, and Aceh. All those high predicted suitable habitats are located along Bukit Barisan Mountains range from Lampung to Aceh (figure 1).

According to the predictive map, there are 13 conservation areas that are predicted as the suitable habitats for the this species including Barumun Wildlife Reserve, Wan Abdul Rahman Grand Forest Park, Semidang Bukit Kabu, Bukit Tiga Puluh National Park, Cut Nyak Dien Grand Forest Park, Dolok Sibual-buali Nature Reserve, Rimbo Panti Nature Recreation Park, Gunung Marapi Nature Recreation Park, Bukit Kaba Nature Recreation Park, Hutan Pinus Nature Reserve, Rimbo Panti Nature Reserve, Siranggas Wildlife Reserve, and Batang Gadis National Park (figure 2).

Soil organic carbon has the highest percent contribution with the value 65.6%, followed by annual precipitation (17.7%) and slope (15.8%). Other variables including carbon exchange capacity, annual mean temperature, and soil pH have value less than 1% (table 1).

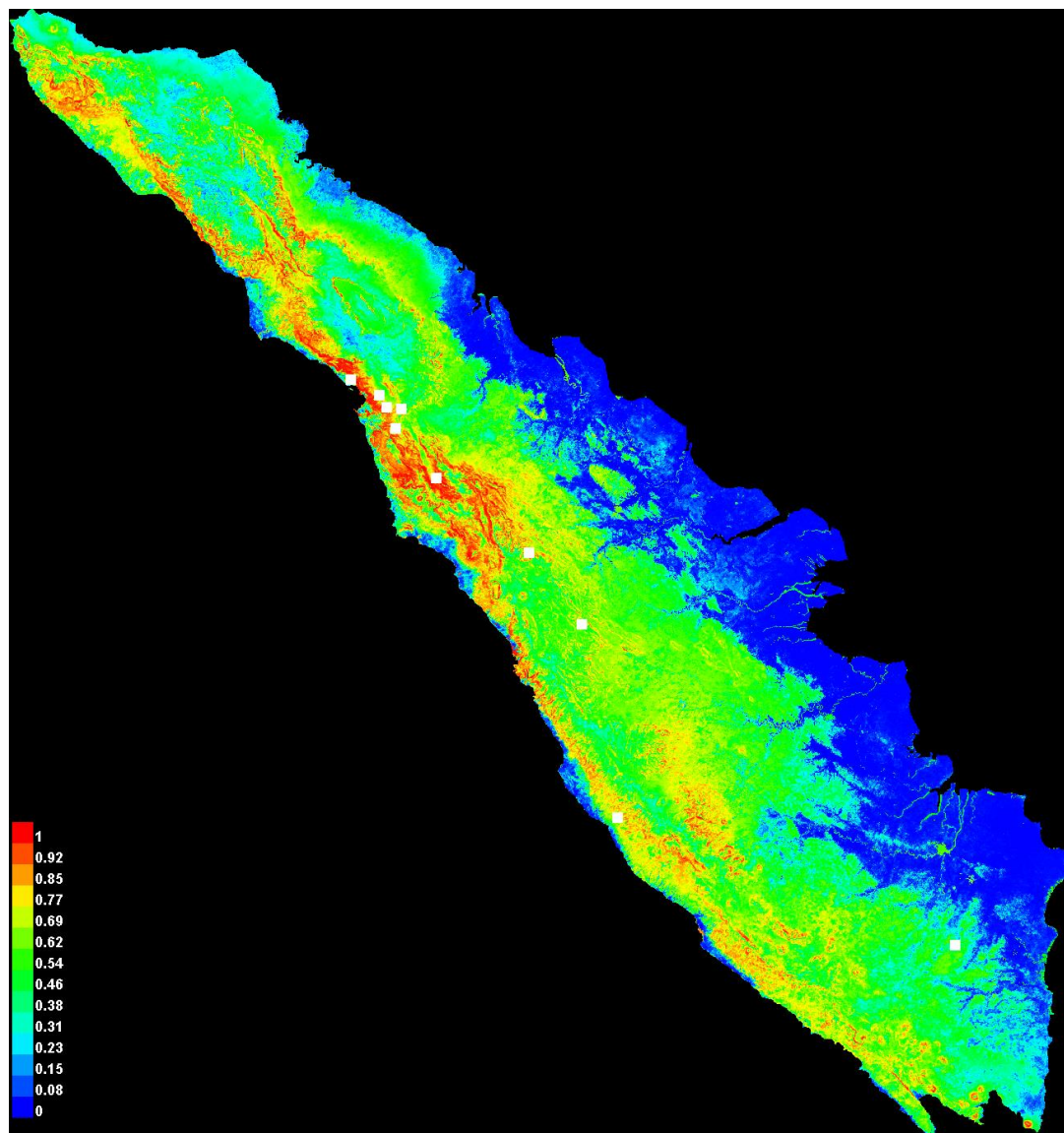


Figure 1. The predictive suitable condition of critically endangered *Nepenthes sumatrana*. The regions with the value more than 0.5 indicating those more suitable habitats for this species, while the regions with the value less than 0.5 indicating those less suitable habitats.

Table 1. Percent contribution of environmental variables in predicting the suitable habitats.

Variable	Percent contribution	Permutation importance
Soil organic carbon	65.6	35.7
Annual precipitation	17.7	37.3
Slope	15.8	24.2
Carbon exchange capacity	0.4	0
Annual mean temperature	0.3	1.6
Soil pH	0.1	0.3
Elevation	0	0.8
Precipitation of driest month	0	0
Precipitation of wettest month	0	0
Land cover	0	0

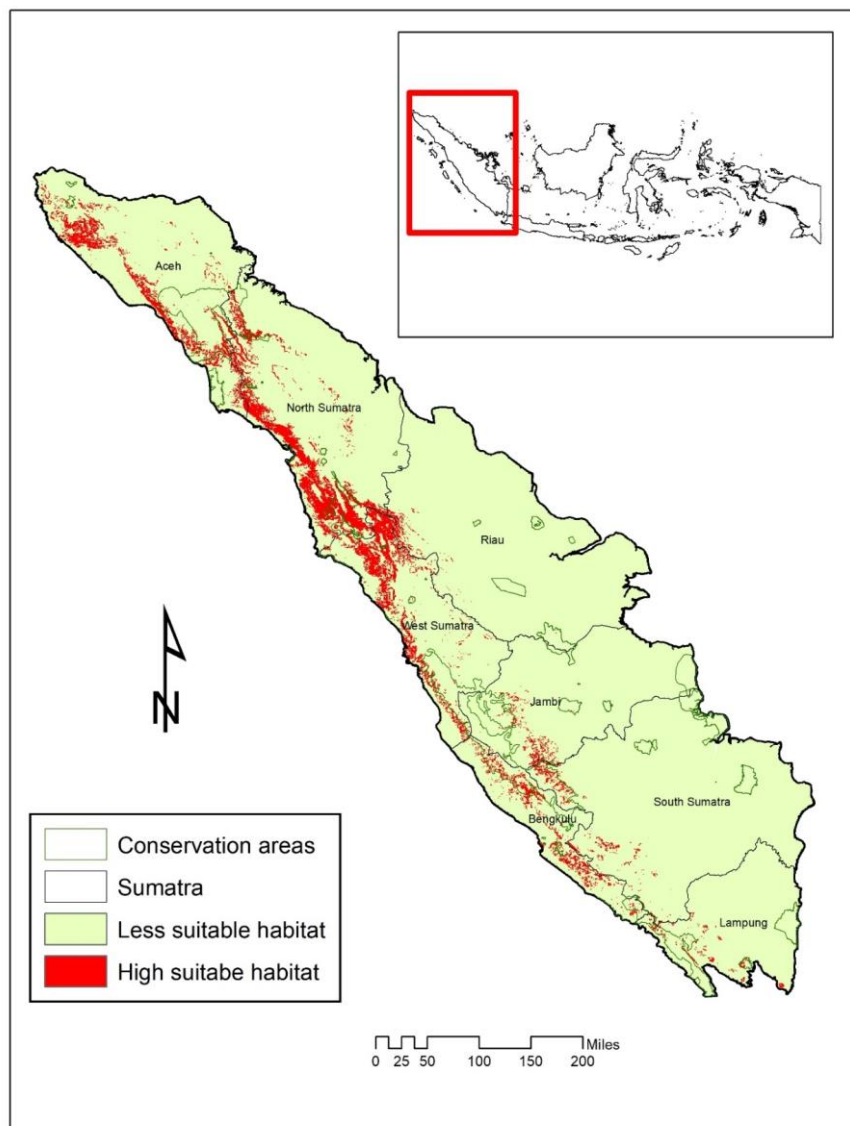


Figure 2. The predicted probability of suitable habitats with the threshold suitability (0.85).

4. Discussion

Predicting habitat suitability of rare and threatened plant remains a challenge due to only few occurrence records are available. In order to resample the small number of occurrence records of *N. sumatrana*, Cross-validation is able to use all the data for evaluation process that applicable for small data sets [31]. The predictive model has AUC value of 0.833 indicating the model has a good performance in distinguishing between presence and absence. Higher value of AUC that close to 1 indicates much better model performance [7, 28]. AUC value has a range from 0 to 1 [32]. An AUC value of 0.5 indicates the model does not perform better than random, whereas the value of 1 indicates perfect discrimination [33]. The predictive model shows the regions in adjacent location where the species is known to occur, are highly predicted as the suitable habitat of *N. sumatrana*. The algorithm of Maximum Entropy (MaxEnt) characterizes the environmental variables in the locations where the species is known to occur, then extrapolate it across the landscape of Sumatra. The suitable habitats of this species are predicted lies on 13 conservation areas in Sumatra. However, the suitable habitats are mostly predicted outside of conservation areas. Those locations provided by predictive suitable habitat map are highly recommended when the inventory efforts will be conducted in the future.

Besides of predicting the habitat suitability, MaxEnt also determines the importance variables that affect the distribution of *N. sumatrana*. Soil organic carbon, annual precipitation and slope are predicted as the important variables that affecting the distribution of *N. sumatrana*. Other variables are not quite important in affecting the distribution of critically endangered *N. sumatrana*. Soil organic carbon contributes the highest values affecting the distribution. Soil organic carbon represents only carbon component of organic compounds. Most *Nepenthes* species grow better in acidic and low nutrient that composed of peat, white sand, sandstone, or volcanic soils [34]. High organic carbon contents creates an increasing water retention in all textures of soil. The soil that has high water retention tends to have higher moisture [35]. It creates a suitable habitat for *N. sumatrana* because this species is found in environment with moist and shady conditions [2]. The second factor that affecting the distribution of this species is annual precipitation. It is considered as an important factor because Sumatra has a relatively diverse precipitation rates among its regions. Most predicted habitats of this species are located along Bukit Barisan Mountains range. The Bukit Barisan Mountains range receives about 2,500 mm of annual rainfall, but the Western slopes receive more rainfall than the Eastern slopes [36]. Bukit Barisan Mountains range consists of Gunung Leuser National Park, Kerinci Seblat National Park, and Bukit Barisan National Park. Those areas receive different precipitation rate in which Gunung Leuser receives 3000–4657 mm of rainfall, Kerinci Seblat receives a rainfall average 2990 mm, and Bukit Barisan receives a rainfall average 3000–4000 m [37]. Slope also contributes the importance variables that affecting the distribution. It is aligned to some previous study that stated this species grew in steep slope [2, 5].

5. Conclusion

The high suitable habitats of *Nepenthes Sumatrana* are identified along Bukit Barisan Mountains range from Lampung to Aceh and mostly predicted in Northern regions of Sumatra including West Sumatra, North Sumatra, and Aceh. Soil organic carbon, annual precipitation and slope are considered as three biophysical variables that important in predicting the habitat suitability of critically endangered *N. sumatrana*.

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References

- [1] Tamin R and Hotta M 1986 *Reports and Collection of Papers Kyoto University Kyoto* 75
- [2] Clarke C M 2001 *Nepenthes of Borneo* (Kinabalu: Natural History Publications in Association with Science and Technology Unit)
- [3] Clarke C M 2014 *The IUCN Red List of Threatened Species 2014*: e.T39700A21845285 <https://dx.doi.org/10.2305/IUCN.UK.2014-1.RLTS.T39700A21845285.en>. Downloaded on 15 July 2021
- [4] Ginting N and Lubis J A 2017 *Jurnal Biologi Lingkungan Industri, Kesehatan BioLink* 3
- [5] Putra H F and Mustaqim W A 2021 *BIODIVERSITAS* **22** 1580
- [6] Fadillah N N, Patana P and Yunasfi 2014 *Peronema Forestry Science Journal* **3** 1
- [7] Elith J, Graham C H, Anderson R P, Dudik M, Ferrier S, Guisan A, Hijmans R J, Huettmann F, Leathwick J R, Lehmann A, Li J, Lohmann L G, Loiselle B A, Manion G, Moritz C, Nakamura M, Nakazawa Y, Overton J M, Peterson A T, Phillips S J, Richardson K, Scachetti Pereira R, Schapire R E, Soberon J, Williams S, Wisz M S and Zimmermann N E 2006 *Ecography* **29** 129
- [8] Peterson A T 2006 *Biodiversity Informatics* **3** 59
- [9] Abdelaala M, Foisa M, Fenua G and Bacchetta G 2019 *Ecological Informatics* **50** 68
- [10] Yudaputra A, Fijridiyanto I and Cropper W P 2020 *Biodiversitas* **21** 326
- [11] Yudaputra A 2020 *Biodiversitas* **21** 674

- [12] Yudaputra A and Hutabarat P 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **743** 012018
- [13] Guisan A and Zimmermann N E 2000 *Ecological Modelling* **135** 147
- [14] Guisan A, Thuiller W 2005 *Ecological Letters*. **8** 993
- [15] Wisz M S, Hijmans R J, Li J, Peterson A T, Graham C H, Guisan A and NCEAS *Diversity Distribution* **14** 763
- [16] Pearson R G 2007 *Synthesis American Museum of Natural History*. Available at <http://ncep.amnh.org>
- [17] Thorn J S, Nijman V, Smith D and Nekaris K A I 2009 *Diversity and Distributions* **15** 289
- [18] Ortega-Huerta M A and Peterson A T 2008 *Revista Mexicana De Biodiversidad* **79** 205
- [19] Hernandez P A, Graham C H, Master L L and Albert D L 2006 *Ecography* **29** 773
- [20] Yudaputra A, Puji Astuti I and Cropper Jr W P 2019 *Biodiversitas* **20** 2321
- [21] *Nepenthes sumatrana* (Miq.) Beck in GBIF Secretariat 2021 GBIF Backbone Taxonomy. Checklist dataset <https://doi.org/10.15468/39omei> accessed via GBIF.org on 2021-07-13
- [22] Farr T G, Rosen P A, Caro E, Crippen R, Duren R, Hensley S, Kobrick M, Paller M, Rodriguez E, Roth L, Seal D, Shaffer S, Shimada J, Umland J, Werner M, Oskin M, Burbank D and Alsdorf D 2007 *Geophys* **45** RG2004, doi:10.1029/2005RG000183. (Also available online at http://www2.jpl.nasa.gov/srtm/SRTM_paper.pdf)
- [23] NASA Shuttle Radar Topography Mission (SRTM) 2013 Shuttle Radar Topography Mission (SRTM) Global. Distributed by Open Topography. <https://doi.org/10.5069/G9445JDF> Accessed: 2021-06-22
- [24] Hijmans R J, Cameron S E, Parra J L, Jones P G and Jarvis A 2005 *International Journal of Climatology* **25** 1965
- [25] Hengl T, Mendes de Jesus J, Heuvelink G B M, Ruiperez G M, Kilibarda M, Blagotić A, Shangguan W, Wright M N, Geng X, Bauer-Marschallinger B, Guevara M A, Vargas R, MacMillan R A, Batjes N H, Leenaars J G B, Ribeiro E, Wheeler I, Mantel S and Kempen B 2017 *PLOS ONE* **12** e0169748
- [26] ORNL D A A C 2018 MODIS and VIIRS Land Products Global Subsetting and Visualization Tool. ORNL DAAC Oak Ridge Tennessee USA. Accessed June 22, 2021
- [27] Phillips S J, Dudik M and Schapire R E 2021 Maxent Software for modelling species niches and distribution (Version 3.4.1). Available from url: http://biodiversityinformatics.amnh.org/open_source/maxent/. Accessed on 2021-6-30
- [28] Peterson A T, Pares M and Eaton M 2007 *Ecography* **30** 550
- [29] Phillips S J, Dudik M and Schapire R E 2004 *Proceedings of the 21st international conference on machine learning* ACM Press New York NY pp 655
- [30] UNEP-WCMC and IUCN 2021 Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM) [Online], July 2021, Cambridge UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net
- [31] Phillips S J, Anderson R P and Schapire R E 2006 *Ecological Modelling* **190** 231
- [32] Fielding A H and Bell J F 1997 *Environmental Conservation* **24** 38
- [33] Swets J A 1988 *Science* **240** 1285
- [34] Barthlott W, Porembski S, Seine R and Theisen I 2007 *The Curious World of Carnivorous Plants* (Portland, Oregon: Timber Press)
- [35] Rawls W J, Pachepsky Y A, Ritchie J C, Sobecki T M and Bloodworth H 2003 *Geoderma* **116** 61
- [36] Whitten A J, Damanik S J, Anwar J and Hisyam N 1987 *Ekologi ekosistem sumatera* (Yogyakarta: Gadjah Mada University Press)
- [37] UNESCO World Heritage 2009 Tropical Rainforest Heritage of Sumatra. <https://whc.unesco.org/en/list/1167>. Accessed July 13, 2021