Species Distribution Modelling to Assist Biodiversity and Conservation Management in Malaysia

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Abstract. Limited resources, including financial, expertise and time have made a case for prioritizing conservation exercises especially in a biodiversity hotspot country such as Malaysia. One method to determine conservation priorities is through Species Distribution Modelling (SDM). Globally, SDM has long been used to assist conservation management by estimating the range area of a species and determining its potential location in different geographical settings. This information will allow governing agencies to pinpoint important areas for conservation. Since management of protected areas in Malaysia is governed by federal or state, several legislation issues have arisen due to conflict of interest between the two authority bodies. This paper aims to review the current usage of SDM in Malaysia and suggest SDM as one of the tools that can be systematically used by both state and federal government in protected area management.

1. Introduction

The increasing rate of population growth, environmental degradation and climate change makes conservation of wildlife and natural resources more challenging than ever [1,2]. In response to this, an array of national and international policy are being implemented with aim to tackle biodiversity loss at a finer scale. The Convention of Biological Diversity (CBD) aims to oversee a significant reduction of biodiversity loss by 2010 [3]. Unfortunately, resource consumption, invasive alien species, over exploitation and climate change showed an increase in rate by 2010 [4]. After failing to meet the 2010 target, the Aichi Targets for 2020 were reasserted to continue the mission [3,4]. One of the issues faced by CBD is the lack of a globally unified observation system to constantly monitor biodiversity change [5]. Similarly, contrasting perception on conservation priorities are also one of the challenges faced by conservation stakeholders in Malaysia. State governments often refused to give up their land for conservation as this is their source of state revenue. Shortage of manpower and incentives from the federal government worsens the situation [6]. Adding on to the issue, limited resources are allocated for

conservation exercise compared to socioeconomic development. To solve this, digital mobilization of biodiversity records is important. This will enable regional biodiversity monitoring and database sharing. With the availability of spatial distribution information of species and remote sensing ecosystem data one can measure across a continuous space and make large scale generalizations. Using statistical models such as Species Distribution Modelling (SDM), one could extrapolate data from point locations to regional or in some cases, global scale. Stakeholders can pinpoint areas with conservation priorities and focus majority of the resources towards conservation of that area. This paper explores the current state of SDM for conservation in Malaysia and the potential of SDM to be a tool in managing protected areas.

2. Conservation management tools used globally

On a global scale, there is a need for a systematic and comprehensive approach to deal with conservation conflicts [7]. These approaches need to be widely applicable across multiple regional boundaries and governing agencies. Example of such approach is the World Database on Protected Areas (WDPA) (www.unep-wcmc.org) which consist of open access data and a mapping tool that contains information on over 200,000 government-managed protected areas. Until recently, information on the WDPA is not made available to the public. With its recent open access capabilities, a larger network of conservation-minded people can contribute to the global biodiversity knowledge database [8].

The IUCN Red List of Threatened Species is also another well-known database that has made a large portion of its information publicly searchable. As an added value, ArcGIS users can download a spatial layer map in ESRI Shapefile format for mapping applications. Another database that utilizes the power of citizen science in conservation management is the Instant Wild application developed by Zoological Society of London [9]. This app relies on crowd-sourced identification of camera traps photographs. Not only this will assist conservation research, it will also generate public awareness to contribute towards conservation efforts. Other similar conservation management tools includes Map of Life [10], Global Forest Watch [11], Tropical Ecology Assessment & Monitoring Network (TEAM) [12] and Biodiversity Indicator Dashboard (BID, http://dashboard.natureserve.org). All these tools either uses Geographic Information System (GIS), Remote Sensing (RS) or Global Positioning System (GPS) to record biodiversity database.

Recent advancements in GIS, RS and GPS have allowed integration of spatial data from publicly available database mentioned above into statistical models such as Species Distribution Modelling (SDM). Each species has a specific habitat requirement for its survival. Environmental requirements such as canopy cover, vegetation cover, distance from road or human settlement largely affects their distribution. SDM is a predictive tool that can generate geographical maps by correlating species presence record and the locality environmental condition [13,14]. These maps are then used to obtain ecological insights and predict possible distributions across different landscapes. SDMs are also often referred to as range maps, habitat models, ecological niche models, spatial models and bioclimatic models.

Ideally, modelling species distribution should be based on data obtained from rigorous sampling design when both presence and absence of species are recorded in a spatially and environmentally represented site [15]. This becomes an apparent issue since absence data is difficult to obtain due to limited resources in most part of the world plus the fact that most studies on species have been extirpated from their original range. To counter this, several methods for habitat modelling that uses presence-only data and pseudo-absences have been developed (Table 1). Presence-only data is the most easily available data in the field of conservation [16]. With the growing number of presence-only field data and development in statistical analysis, SDM has become increasingly popular throughout the years for a variety of applications such as monitoring climate change, identifying species diversity through spatial pattern, managing invasive species, mapping the spread of vector-borne diseases; and identifying protected areas for conservation and species reintroduction [17, 18, 19, 20,21,22]. Basically, SDM correlates environmental variables provided and determines the most effective variable that controls the

distribution of species. At the same time, SDM can predict probability of occurrence and environmental requirement of a species. This acts as a bridge in species conservation, connecting science and wildlife management.

Table 1. Table of species distribution models that uses presence-only data.

Model name	Model class	Reference
BIOCLIM	Envelope model. Abundance of species is determined by climatic limits	[23]
DOMAIN	Distance based method, multivariate distance.	[24]
GARP	Uses genetic algorithm for rule-set production	[25]
ENFA	Using concept of ecological niche, compares the multidimensional space of ecological variables	[26]
MaxEnt	Maximum entropy	[13]

3. SDM for Conservation in Malaysia

Malaysia is a biologically megadiverse developing country. Conservation of its biodiversity must be balanced with is economical development. Limited resources such as financial allocation, manpower and land area has brought in a need for a faster and efficient way of conservation management. Here the potential of SDM to be used as a tool for conservation management in Malaysia is presented.

SDM consist of two elements, the species presence data and the environmental variable. Species presence data could be obtained either from direct field records or publicly available database. Environmental variables such as the Enhanced Vegetation Index (EVI) or Normalized Difference Vegetation Index (NDVI) can be obtained through remote sensing. The Malaysian Remote Sensing Agency (MRSA) is an agency under the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). It oversees supporting agencies that manage agriculture production, natural resources, environment and land development. MRSA has developed several applications that directly assist management of natural resources such as the Forest Monitoring System using Remote Sensing (FRMS) and MyGeoBioD. These applications allow monitoring of forest activities such as logging or natural disaster through high resolution satellite images and systematically stores the local flora and fauna geographical data in its database. Users will be able to retrieve GIS data from MyGeoBioD to be used in conservation management. In the recent Strategic Plan of Action for Sabah, the Ministry of Water, Land and Natural Resources (KATS) plans to enlarge the concept of MyGeoBioD to other countries in Borneo. Application of SDM in Malaysia would require the involvement of MRSA as they are the major provider for most of the presence-only data and remotely sensed environmental data. For locations that lack presence-data, a localized sampling schemes have to be implemented. While this may take more time and money, it is necessary to provide baseline data for consequent modelling, conservation and management purposes.

4. Species distribution modelling for conservation management in Malaysia

Species distribution modelling is relatively new in Malaysia. The growing, published literature that uses species distribution modelling as part of a conservation practice in Malaysia is reviewed here. We use this review to highlight the current works on species distribution models and explore the potential of SDM to be systematically implemented in conservation practice by the Malaysian stakeholders. A total

of 12 papers touches on the application of species distribution modelling in the field of conservation in Malaysia (Table 2).

Table 2. Published works on species distribution modelling in Malaysia

Organism	Type of application	Method used	Reference
Tapir (*Tapirus indicus*)	(i)Determine potential distribution of an endangered species for habitat conservation (ii)Estimate population density (presence-absence data)	(i)MaxEnt (ii) CAPTURE	[27, 28, 29]
Sunbear (*Helarctos malayanus)*	(i) Determine potential distribution and habitat requirement an endangered species	(i) ENFA & Maxent (ii) ENFA	[30, 31]
Dugong	Modelling habitat associations of dugongs and potential bycatch risk	MaxEnt	[32, 33]
Greater Mouse Deer (*Tragulus nipu*) Lesser Mouse Deer (*Trigulus javanicus*)	Predicting suitable habitat for *T.nipu* and *T.javanicus* Compare habitat limitation of both species	MaxEnt	[34]
Indian mackerel (*Rastrelliger kanagurta*)	Describe the effects of oceanographic factors on Indian mackerel distribution.	MaxEnt	[35]
Dipterocarps (*Dipterocarpus lamellatus)* (*Dipterocarpus ochraceus*)	Predict the extent of historic species distribution and estimate the amount of habitat loss in Sabah	MaxEnt	[36,37]
Flat-headed cat (*Prionailutus planiceps*)	Reassess potential current distribution and conservation status of flat-headed cats	MaxEnt	[38]

Majority of published works used MaxEnt as their modelling method. [39] compared over 16 modelling methods that use both presence and presence/absence data to evaluate the best performing model to predict species distribution. GARP and BIOCLIM are amongst the tested models and results show that presence-only methods were effective in modelling species distributions in many regions. They also discovered that newer modelling methods such as MaxEnt show considerable promise for ecological application. Their findings added with MaxEnt's extreme simplicity of use has made it one of the most used SDM algorithm. As the field of ecological modelling is expanding, it is important for stakeholders in Malaysia to use SDM as a tool for conservation management. Database compilation can be extracted from sighting and field survey data from MyGeoBioD, Department of Wildlife and National

Parks Malaysia, WWF Malaysia, and previous checklist and literature. Sets of environmental variables are used as proxies for biological resources. These include bioclimatic variables, altitude, land cover and vegetation cover. Future application that could be applied in Malaysia includes identifying the best areas to install camera traps for wildlife monitoring and pin pointing locations that connect habitat islands in highway fragmented areas to install viaducts.

5. Conclusion

The biodiversity of a nation is crucial for a nation's survival. Any development effort or policy formation should include the regional biodiversity as a fundamental component. For conservation effort to achieve maximum impact under limited resources, stakeholders need to concentrate their effort heavily (but not solely) on the spots with the richest biodiversity. Any resources invested towards a protected area should be proportional to their contribution in the regional biodiversity. SDM allows stakeholders to make informed decisions on where to focus their effort. Research on SDM in Malaysia is still insufficient in spite of the rich biodiversity that the country holds. Lack of access to locality data might pose a challenge for stakeholders to implement SDM in Malaysia. A systematic effort to implement species distribution modelling in Malaysia is needed to allow for better conservation management. At the same time, the federal and state government should also have a unified conservation exercise to provide balance between conservation and economical development.

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