International Environmental Modelling and Software Society (iEMSs)
2010 International Congress on Environmental Modelling and Software
Modelling for Environment's Sake, Fifth Biennial Meeting, Ottawa, Canada
David A. Swayne, Wanhong Yang, A. A. Voinov, A. Rizzoli, T. Filatova (Eds.)
http://www.iemss.org/iemss2010/index.php?n=Main.Proceedings

Habitat models as a research gap in biodiversity conservation in tropical rain forest of southeast Asia

Mona Nazeri (Corresponding author)

Faculty of Forestry, Universiti Putra Malaysia, 43400, UPM, Serdang, Selangor, Darul Ehsan, Malaysia.

E- mail: gs21551@mutiara.upm.edu.my, monanazeri@msn.com

Kamaruzzaman Jusoff

Faculty of Forestry, Universiti Putra Malaysia 43400, UPM Serdang, Selangor Darul Ehsan, Malaysia

E-mail: kamaruz@forr.upm.edu.my

Nima Madani

Faculty of Forestry, Universiti Putra Malaysia 43400, UPM Serdang, Selangor Darul Ehsan, Malaysia

E-mail: nimamadani@msn.com

Abstract: Tropical rain forests, the richest terrestrial ecosystem on earth are disappearing due to land use changes mainly agricultural activities and timber logging. Habitat alteration and as a result fragmentation have direct effect on species survival trough lose of connectivity between suitable habitats. Without a doubt the traditional strategies for protecting different wildlife species in this region was not successful enough to guarantee the survival of remaining biodiversity. Distribution modelling which, very little has been studied in the region, is significantly important for biodiversity conservation programs. Distribution data can determine all the areas that can have high potential of occupancy by certain species. By conserving all these areas that could be part of endangered species habitat, conservation strategies would be more effective. Recently development of geospatial technology (GIS, RS, GPS), made the possible way to study wildlife and their habitat. Integrating these technologies with habitat models made a robust tool for understanding wildlife habitat relationships. *This paper highlights the need for using habitat models to determine species distribution with a focus of the tropical area and makes a review on some of these techniques.*

KEY WORDS: Species Distribution Model, Habitat Model, Conservation, Tropics

Introduction

The Earth is now facing the crisis of global extinction of biodiversity. Undoubtedly this extinction is due to human activates in recent centuries. With increasing of human population and demand on food supply, natural habitats are converting to rural and agricultural areas and many species are going to extinct (Pimm, 1995). If deforestation continues at a current rate (7.3 million hectare/year) (Fao, 2005) most of the habitats including protected areas may also affect by process of fragmentation and losing connectivity. Our data on threatened species are very limited. Only about 2.5% of the world estimated 1.8 million described species have been assessed for IUCN Red list and within this assessment 38% of the species have been classified as threatened and 1.9% as extinct (IUCN, 2008).

As human destructive activities are occurring in global level, the use of new technologies to study ecosystems and species is apparent. Ecological studies need to determine the complex relationships of species and habitat. Species distribution models (SDM) can reveal some of the important factors limiting species distribution. Moreover, data can be applied in GIS based models to define the species habitat relationships. Distribution modelling of species can help us to define the core habitats which are mostly suitable to fulfil species requirements for survival. While tropical rain forests are known as biological hotspot, less study has been done for determining the potential distribution of species. Distribution modelling in tropical areas with high rate of deforestation and losing connectivity is critically important for species management programs. This technique can be divided in two stages of gathering field data, which is species occurrence map and environmental data can be derived from remote sensing images and GIS layers.

This paper highlights the need for using SDM to determine species distribution with a focus of gap research in tropical area with concentration on Malaysia and makes a review on some of these techniques.

Significant of Tropics

Tropical rain forest ecosystem has a globally significant value due to species richness and their complexity (Gaston, 2000) Deforestation, fragmentation unsustainable hunting of tropical forests are the greatest threats to biodiversity and nature conservation in the ongoing sixth extinction (Dirzo, 2003; Margaret, 2003; Wright, 2005). Tropical forests represent less than 7% of land surface, but contain more than half the species of plants and animals (Mayers, 1992; Roy, 2002). Land use and forest cover are changing in the tropical rain forest. Approximately, half of the potential of dense tropical forest canopy has been removed and converted to other land use (Wright, 2005) even though moist tropics store most of the world's records for local biodiversity(Dirzo, 2003) Tropical deforestation is responsible for the mass extinction of species and it has an effect on biodiversity in different ways such as habitat degradation and also isolation of formerly continuous forests in forest fragments (Pimm, 1995; Roy, 2002) these invaluable ecosystems are important habitat for threatened mammals such as Rhino , Tiger, Leopard, Clouded Leopard, Sun Bear, Tapir, Sambar Deer.

It is increasingly recognized that the disappearance of forests in tropical rain forest will create a number of serious environmental problems that have negative impact on biodiversity (Roy, 2002).

Analysis of wildlife habitat is considered more important for management and planning of protected areas. The effects of fragmentation and habitat loss are modified by landscape configuration, specifically the size, shape and layout of habitat fragments (Saunders, 1991).With decreasing size and increasing fragmentation of habitats, it has become imperative to develop maps of habitat quality for habitat conservation intact.

Species Distribution models

Each species has some requirements based on its behavioural, biological, genetics and evolutionary history to choose a habitat for survival and each habitat must provide these species requirements. By identifying species requirements within habitats we can define suitable areas for species survival. This issue is critical, especially in tropical areas with high species richness that the habitat is losing the suitability due to human pressure.

The history of the models is back to 1976 when Habitat Evaluation Procedure (HEP) was developed by U.S. Fish and Wildlife Service. Since then habitat suitability modes have become a non- separable component of wildlife management ecosystem conservation. The main objectives of Habitat modelling are predicting distribution of wildlife species in geographical area with high species diversity (Butterfield, 1994), locating of species of concern (Sperduto, 1996), predicting area of suitable habitat that may not be currently used by species(Lawton, 1991) and aid to species re-introduction or prediction of the spread of an introduced species (for more detail refer to Table 1). They can also be used to predict species richness, presence or absence of a species(Butterfield, 1994) , probability of a species occurrence (Austin, 2007), or an index of habitat suitability for a species(Hepinstall, 1996) .

Table 1: some potential application of habitat suitability models (modified from (Manel, 2001)& (Guisan 2005))

Field of application	Type of usage	References
Conservation Biology	Identifying habitat for reintroducing species Identifying core habitats Identifying the effective variables in influencing specie distribution Providing spatially explicit assessment of habitat suitability Predicting habitat suitability for the area that no information about the occurrence of species	(Yáñez, 2000; Rotenberry, 2006; Anderson, 2009; Beaumont, 2005; Chefaoui, 2005)
Landscape Ecology	Incorporate landscape structure and composition variables such as habitat patch size, edge effects and juxtaposition and interspersion of habitat requisites. Incorporating habitat quality in to models of wildlife population viability	(Larson, 2004)
Applied Ecology	Predict distributional change in response to changing climate or land use	(Buckland, 1993)

Marine Ecology	supporting the implementation of environmental legislation, integrated coastal zone management, ecosystem-based fisheries management, marine protected areas, habitat identification, mapping coral habitat and determining the effective factors in distribution	(Galparsoro et al., 2009; Skov, 2008; Praca, 2008; Davies et al., 2008; Dolan, 2008)
Invasive Ecology	Predict sensitive habitat to invasive species Model negative effect of non-indigenous species on native biota	(Strubbe, 2009)

In many cases, where conservation and management decisions must be made in a relatively short period of time with limited information (Palma, 1999) habitat modelling play significant role. These techniques can create large-scale predictions of habitat suitability for wildlife species, without detailed knowledge of their physiology and behaviour. Furthermore, using habitat models can be a cost-effective and productive endeavour. Habitat models simplify the representation of Ecological processes which are very complex and too difficult to show every factor that influences species distribution or abundance (Reichert, 1997).They are working on the basis of the fact that the particular habitat variables can explain significant patterns in species distribution or abundance.

Species habitat modelling relies on number of implicit assumptions. The success of habitat models is ultimately related to the existence of strong and predictable associations between species and habitat variables (Cardillo, 1999) . Habitat models are based on key ecological concepts such as niche because of the inclusion of biotic interactions and competitive inclusion in the observed data and carrying capacity by assuming equilibrium between the species and their pattern of occurrence in the habitat.

Although many methods have been used to model habitat suitability (Guisan, 2000), these methods could be classified into two groups, those that require presence – absence data and those required only presence data of species. Most of the commonly used modelling for model construction are based on multiple regression methods and require binary data (Williams, 2003). Generalized additive modelling (GAM; (Hastie, 1986)) , discriminate function analysis (Davis, 1990) , generalized linear modelling (GLM); (McCullagh, 1989), and artificial neural networks (ANN) (Özesmi, 1999)), are some examples of modelling that uses presence – absence data. More recently, methods of habitat modelling that only use presence –only data have been developed (table 2), such as genetic algorithm for rule set prediction (GARP; (Stockwell, 1999)) Ecological Niche Factor Analysis (ENFA; (Hirzel, 2002a)) and MaxEnt (Maximum Entropy; (Phillips, 2006)) BIOCLIM (Climatic Envelope (Busby, 1991)) DOMAIN (Climatic Envelope; (Carpenter, 1993)). These methods by using only presence data allow us to use data where knowledge of absences is inadequate or not trustable (Carpenter, 1993; Hirzel, 2002b). Especially in Tropical forests where lack of data in obvious using present only data in recommended.

Table 2: Presence – only data species distribution models, references and links

Tool	**Methods implemented**	**Reference**	**URL**
Biomapper	ENFA	(Hirzel, 2002b)	http://www.unil.ch/biomapper
MaxEnt	Maximum Entropy	(Phillips, 2006)	http://www.cs.cmu.edu/~aberger/maxent.html
GARP	Genetic Algorithm for Rule- set Production	(Stockwell, 1999)	http://www.lifemapper.org/desktopgarp
BIOCLIM	Climatic Envelope	(Busby, 1991)	http://www.arcsripts.esri.com

DOMAIN	Climatic Envelope	(Carpenter, 1993)	http://www.cifor.cgiar.org/docs/_ref/research_toos/domain/index.htm

All of these models are based on the concept of ecological niche(Hutchinson, 1957). They use some rules and mathematical algorithms to define the ecological niche of the species based on the distribution that build on multidimensional environmental space and after defining niche of species, it is projected in to the geographical space and then produces a predictive map.

Even though habitat models have got some Limitations which have been subject of debate such the fact that in reality habitat is not the only factor that determines the distribution of species and inter specific interactions such as competition and prediction could have a significant effect on the distribution and abundance of certain species, they are still known as one of the most appropriate tools for evaluation of habitat suitability or quality.

Conclusion

Tropical forests are the habitat of many species, which are mostly unknown to scientists. Using habitat models can help us to better manage and conserve species in this sensitive and invaluable habitat. Despite the great implications' distribution habitat models in areas such as Tropics, unfortunately less studied to have conducted using these techniques for conservation of species in Tropics. Habitat modelling encounter with GIS and remote sensing play an important role in measuring habitat characteristic in a large scale and monitoring the changes occurs to the habitat as a result of a natural or human process during different temporal scales.

Research on species distribution models in the south East Asia, especially in Malaysia is more insufficient than other regions, which remains in contrast with the high biodiversity held by tropical ecosystems. Scarcity and deficiency of accurate locality data of species due to inaccessibility are a main reason of not using specie distribution models in this region.Because of scarcity of Point locations for most species in Southeast Asia no systematic and comprehensive effort on species distribution modelling for Southeast Asia had been applied and most of the studies about habitat suitability are made by deductive ways and only shows on a polygon which is not showing the relationship of eco-geographical variables with the focal species.

Future efforts should focus more on using different model in these areas and find the suitable methods regarding to homogeneity environment. At the same time, they should be able to consider environmental change scenarios in order to understand better and manage human interferes in distribution of species.

References

Roy, P.S., Dutt, C.B.S., Joshi, P.K. Tropical forest resource assessment and monitoring. *Tropical Ecology*. 43,21-37, 2002.

Saunders, D.A., Richard, J. H., Chris R. M. Biological Consequences of Ecosystem Fragmentation: A Review. *Conservation Biology*. 5(1),18-32,1991.

Butterfield, B.R.B., Csuti,J.M.S. Modeling vertebrate distribution for Gap analysis. In: R.I.Miller, e., editor, Mapping the diversity of nature. London: Chapman and Hall, p. 53- 68, 1994.

Sperduto, M.B., Congalton. Predicting rare orchid (small whorled pogonia) habitat using GIS. *Photogrammetric Engineering and Remote Sensing*,62:1269-1279, 1996;.

Lawton, J.H., Woodroffe,G.L. Habitat and the distribution of water volves: why are there gap in a species range? *Journal of Animal Ecology*,60:79-91, 1991.

Austin, M. Species distribution models and ecological theory: A critical assessment and some possible new approaches. *Ecological Modelling*,200(1-2):1-19,2007.

Hepinstall, J.A., Queen,L.P.,Jordan,P.A. Application of a modified habitat suitability index model for moose. *Photogrammetric Engineering and Remote Sensing*,62:1281-1286,1996.

Manel, S., Wiliams,H.C.,Ormerod,S.J. Evaluating presence- absence models in ecology: the need to account for prevalence. *Journal of Applied Ecology*,38:921-931, 2001.

Guisan , A., .Thuiller,W. Predicting species distribution: offering more than simple habitat models. *Ecology Letters*,8(9):993-1009,2005.

Yáñez, M., .Floater, G. Spatial distribution and habitat preference of the endangered tarantula, Brachypelma klaasi (Araneae: Theraphosidae) in Mexico. *Biodiversity and Conservation*, 9(6):795-810,2000.

Rotenberry, J.T., Preston,K.L.,Knick,S.T. GIS- based niche modeling for mapping species habitat. *Journal of Ecology*,87(6):1458-1464, 2006.

Anderson, B.J., Arroyo, B. E., Collingham, Y. C., Etheridge, B. F., Javier, G., Simon ,G., Richard, D. L., Fiona ,M. S., Innes, M. W.,Thomas, C. D., Travis, J. R., Steve, M. Using distribution models to test alternative hypotheses about a species' environmental limits and recovery prospects. *Biological Conservation*,142(3):488-499,2009.

Beaumont, L.J., Hughes, L., Poulsen, Michael. Predicting species distributions: use of climatic parameters in BIOCLIM and its impact on predictions of species' current and future distributions. *Ecological Modelling*,186(2):251-270,2005.

Chefaoui, R.M., Hortal, J.,Lobo, J. M. Potential distribution modelling, niche characterization and conservation status assessment using GIS tools: a case study of Iberian Copris species. *Biological Conservation*. 2005;122(2):327-338.

Larson, M.A., Thompson Iii, F. R.,Millspaugh, J. J.,Dijak, W. D.,Shifley, S. R. Linking population viability, habitat suitability, and landscape simulation models for conservation planning. *Ecological Modelling*,180(1):103-118, 2004.

Buckland, S.T., Elston,D.A. Emprical models for the spatial distribution of wildlife. *Journal of Applied Ecology*,30:478-495, 1993.

Galparsoro, I.; Borja, Á.; Bald, J.; Liria, P.; Chust, G. Predicting suitable habitat for the European lobster (Homarus gammarus), on the Basque continental shelf (Bay of Biscay), using Ecological-Niche Factor Analysis. *Ecological Modelling*,220(4):556-567, 2009.

Skov, H., Humphreys, E.,Garthe, S.,Geitner, K.,Grémillet, D.,Hamer, K. C.,Hennicke, J.,Parner, H.,Wanless, S.,. Application of habitat suitability modelling to tracking data of marine animals as a means of analyzing their feeding habitats. *Ecological Modelling*,212(3-4):504-512, 2008.

Praca, E., Gannier, A. Ecological niches of three teuthophageous odontocetes in the northwestern Mediterranean Sea. *Ocean Sci*,4(1):49-59, 2008.

Davies, A.J.; Wisshak, M.; Orr, J.C.; Murray Roberts, J. Predicting suitable habitat for the cold-water coral Lophelia pertusa (Scleractinia). Deep Sea Research Part I: Oceanographic Research Papers,55(8):1048-1062,2008.

Dolan, M.F.J., Grehan, A.J.,Guinan, J. C.,Brown, C. Modelling the local distribution of cold-water corals in relation to bathymetric variables: Adding spatial context to deep-sea video data. Deep Sea Research Part I: Oceanographic Research Papers,55(11):1564-1579, 2008.

Strubbe, D., Matthysen, E. Predicting the potential distribution of invasive ring-necked parakeets Psittacula krameri in northern Belgium using an ecological niche modelling approach. *Biological Invasions*,11(3):497-513, 2009.

Palma, L., Beja,P.,Rodrigues,P. The use of sighting data to analyse Iberian lynx habitat and distribution. *Journal of Applied Ecology*. 1999;36(5):812-824.

Reichert, P., Omlin,M. On the usefulness of overparametrized ecological models. *Journal of Ecological Modeling*,95:289-299, 1997.

Cardillo, M., Macdonald, D.W., Rushton, S.P. Predicting mammal species richness and distributions: testing the effectiveness of satellite-derived land cover data. *landscape Ecology*,14(5):423-435, 1999.

Guisan, A., Zimmermann, N. E. Predictive habitat distribution models in ecology. *Ecological Modelling*,135(2-3):147-186, 2000.

Williams, A.K. The influence of probability of detection when modeling species occurrence using GIS and survey data [Virginia]: *Virginia Polytechnic Institute and State University*, 146 p,2003.

Hastie, T., .R.Tibshirani. Generalized additive models. *Statistical Science*,3:297-318,1986.

Davis, F.W., Stoms,D. M.,Estes,J. E.,Scepan,J.,Scott,J. M. An information systems approach to the preservation of biological diversity. *International Journal of Geographical Information Science*,4(1):55 - 78,1990.

McCullagh, P., Nelder,J.A. Generalized linear models: Chapman and Hall,1989.

Özesmi, S.L., Özesmi,U. An artificial neural network approach to spatial habitat modeling with interspecific interaction. *Ecological Modelling*,116:15-31,1999.

Stockwell, D. The GARP modelling system: problems and solutions to automated spatial prediction. *International Journal of Geographical Information Science*,13(2):143 - 158,1999.

Hirzel, A., Guisan, A. Which is the optimal sampling strategy for habitat suitability modelling. *Ecological Modelling*,157(2-3):331-341,2002a.

Phillips, S.J., Anderson, R.P.,Schapire, R.E. Maximum entropy modeling of species geographic distributions. Ecological Modelling,190(3-4):231-259,2006.

Busby, J.R. BIOCLIM - a bioclimatic analysis and prediction system. *Nature Conservation*: cost effective biological surveys and data analysis,. p. 64-68,1991.

Carpenter, G., Gillison, A. N.,Winter, J. DOMAIN: a flexible modelling procedure for mapping potential distributions of plants and animals. *Biodiversity and Conservation*,2(6):667-680,1993.

Hirzel, A.H., Hausser, J.,Chessel, D.,Perrin, N. Ecological-Niche Factor Analysis: how to compute habitat suitability maps without absence data? *Ecology*,83(7):2027-2036,2002b.

Hutchinson, G.E. Concluding Remarks. Cold Spring Harbor Symp. *on Quant.biology*,p. 415-427,1957.