USING MAXENT TO ASSESS THE IMPACT OF CLIMATE CHANGE ON THE DISTRIBUTION OF SOUTHERN YELLOW-CHEEKED CRESTED GIBBON (*Nomascus gabriellae*)

Vu Tien Thinh[1], Tran Van Dung[2], Luu Quang Vinh[3], Ta Tuyet Nga[4]
[1,2,3,4] *Vietnam National University of Forestry*

SUMMARY

Climate change has a variety of impacts that might have negative impacts on wildlife species, especially their distribution. Species with narrow distributions are are more sensitive than the other species. In this study, we used ecological niche modelling species (MaxEnt software), species occurrence data, and environmental variables to assess the impacts of climate change on the distribution of Southern yellow-cheeked crested gibbon (*Nomascus gabriellae*) - an endemic and rare primate species of Vietnam and Cambodia with narrow distribution range. We used environmental variables to generate the potential distribution of Southern Yellow-cheeked Crested Gibbon at current and two times in future (2050 and 2070). In addition, two scenarios of climate change (RCP4.5 and RCP8.5) and three climate models (ACCESS1 - 0; GFDL - CM3; MPI - ESM - LR) were used to evaluate the changed of suitable distribution in the future. The results show that the distribution of this species was predicted to decrease dramatically under the effects of climate change. Futhermore, the projections indicate that a larger suitable area will disappear. The suitable areas are likely to shift toward the center of current distribution range and areas with high elevation above sea level. In addition, we assessed the priority of protected areas in gibbon conservation under climate change context.

Keywords: Climate change, Gibbon, ecological niche modelling, Maxent, Nomascus.

I. INTRODUCTION

Southern Yellow-cheeked Crested Gibbon (SYCCG) (*Nomascus gabriellae*) is an endemic primate species of Indochina, this species is only recorded in the Southern of Vietnam and the Northeast of Cambodia (Van Ngoc Thinh et al., 2010; Rawson et al., 2011). Recently, the population of SYCCG has been rapidly decreasing. The main threats to the species are habitat loss, hunting (Geissmann et al., 2000; Rawson et al., 2011). This species is listed as Endangered on the IUCN Red List (Geissmann et al., 2008). Gibbons are highly sensitive to living environment because of narrow ecological niche. They are often recognized in tall evergreen and semi-evergreen forest (Geissman et al., 2000) and in the cool climate area (Pham Nhat, 2002).

Climate change is one of the main causes of biodiversity loss, that is the direct impact component and the consequences are obvious. To adapt to the changes of climate, wildlife species might shift their distribution poleward or shift to higher areas where the ecological conditions are more suitable for them (Root and Schneider, 2002). Recent studies have shown that a variety of primate species are significantly affected by climate change in the 21st century, especially in Southeast Asia as a hot spot (Graham et al., 2016) due to small distribution range and narrow ecological niche (Estrada et al., 2017; Sesink-Clee et al., 2015). Especially, gibbons are predominantly frugivorous, but the diet also includes leaves, shoots and flowers (Nadler and Brockman, 2014). Therefore, climate change is also likely to impact on their food sources (Wiederholt and Post., 2010). Climate change also results in fragmentation or loss of habitat, which is one of the most serious threats to the primate populations. In this study, we of assess the impact of climate change on the distribution of SYCCG. The study aims to achieve the following objectives: (1) predicting the potential distribution of SYCCG at current and the future; (2) assessing the change of the potential distribution caused by climate change; (3) determining the priority areas for gibbon conservation in the climate change context.

II. RESEARCH METHODOLOGY

2.1. MaxEnt model

MaxEnt is software that uses predictive methods to simulate the potential distribution of species from existing information (Phillips et al., 2006). Species occurrence data is used as an input (called occurrence data), along with the use of environmental condition variables (such as temperature, rainfall, etc.) to interpolate the likelihood of occurrence for each grid cell. This model is the most popular among ecological niche modeling programs. Several studies have used MaxEnt to assess the effect of climate change on primate's species such as Sesink-Clee et al. (2015), Gouveia et al. (2016). In addition, the newest MaxEnt version can be downloaded free from http://biodiversityinformatics.amnh.org/open_source/maxent/. In this study, the following indexes were used: percentage of random sample to test = 20%, regularization multiplier = 0.2, maximum iteration = 1,000, convergence threshold = 0.001, maximum number of background points = 10,000.

The area under the response curve (AUC), with values ranging from 0 to 1 was used under application of the Receiver Operator Characteristic model (ROC) to determine model suitability (Phillips, 2006). In this context, models with AUC values > 0.75 (larger values meaning higher model suitability) are usefull in modeling species distribution (Elith, 2000). When the AUC = 1, the predictive power of the model is considered perfect. If the AUC < 0.5, the predictive power of model is low (Phillips, 2006).

MaxEnt generated a projection showing levels of suitability for SYCCG with the value ranging from 0 to 1 for each pixel. Cells with greater values represented higher suitability. This projection was generated in ASCII (*.asc) format, then it was converted into raster format (*.tif) by ArcMap10.1. In this study, we used the value "equal training sensitivity and specificity" to classify suitable level (> 0.1) and unsuitable level (0 - 0.1). Then the suitable level was divided into 3 categories: Highly potential (> 0.5); moderately potential (0.3 - 0.5); and low potential (0.1 - 0.3).

Finally, to assess the priority areas for conservation of SYCCG, we used 02 criteria. Firsts, we calculated the area of species distribution in each protected area lost due to the effect of climate change. All protected areas were evaluated with scores ranging from 1 - 5 points for different scenarios of climate change. If the suitable area decreased by less than 20% of the current distribution range, the protected area was assigned 5 points. Similarly, the protected area was assigned 4 points (21 - 40%); 3 points (41 - 60%); 2 points (61 - 80%) and 1 point (more than 80%), respectively. The second criteria used the number of gibbon group in each protected area. The area will receive 5 points, 3 points if the number of gibbon group in this area is larger 10 groups and less than 10 groups, respectively. If the gibbon was previously recorded in the protected area but no recent records were confirmed, the protected area was assigned 1 point. The maximum point for each protected areas was 65 points. Therefore, we divided the protected areas into 3 levels: high priority (41 - 65 points), medium priority (21 - 40 points) and low priority (1 - 20 points).

2.2. Species occurrence data

We gathered a total of 431 independent localities at that the occurrence of *N. gabriellae* during field surveys and from previous studies, including Dong Thanh Hai et al. (2011); Pollard et al. (2008); Hoang Minh Duc (2010); Hoang Minh Duc et al. (2010a), (2010b); Ngo Van Tri (2003); Nguyen Manh Ha et al. (2010); Channa and Gray (2009); Tran Van Dung (unpublished), Vu Tien Thinh et al. (2016); and Cat Tien National Park (2004).

2.3. Environmental variables

* *Present climate data*

We gathered environmental variables from Wordlclim (http://www.worldclim.org/) (Hijmans et al., 2005) (table 1). The spatial resolution of the variables is 0.83 x 0.83 km. The range of climate data used to run the model covered the Indochina region, the Southern of China and a part of Thailand.

To eliminate highly correlated variables, data from 2,000 randomly selected points in the region was exported to Excel for calculating the correlation coefficient. The Pearson correlation coefficient was used to calculate the correlation between pairs of variables. We used only one variable in the pairs having a coefficient of correlation | r | > 0.85 for subsequent analysis. Finally, we used 8 variables, including: 04 temperature variables and 04 precipitation variables (Table 1) for final modelling.

Table 1. The environmental variables used to run model

Variables	Source	Data type
BIO1 = Annual Mean Temperature	Worldclim	Continuous
BIO2 = Mean Diurnal Range (Mean of monthly = max temp - min temp)		
BIO3 = Isothermality (BIO2/BIO7) (*100)		
BIO4 = Temperature Seasonality (standard deviation *100)		
BIO5 = Max Temperature of Warmest Month		
BIO6 = Min Temperature of Coldest Month		
BIO7 = Temperature Annual Range (BIO5 - BIO6)		
BIO8 = Mean Temperature of Wettest Quarter		
BIO9 = Mean Temperature of Driest Quarter		
BIO10 = Mean Temperature of Warmest Quarter		
BIO11 = Mean Temperature of Coldest Quarter		
BIO12 = Annual Precipitation		
BIO13 = Precipitation of Wettest Month		
BIO14 = Precipitation of Driest Month		
BIO15 = Precipitation Seasonality (Coefficient of Variation)		
BIO16 = Precipitation of Wettest Quarter		
BIO17 = Precipitation of Driest Quarter		
BIO18 = Precipitation of Warmest Quarter		
BIO19 = Precipitation of Coldest Quarter		

* *Variable in bold are used for final analysis*

- *Climate scenario*

To predict the changed of SYCCG's distribution in the future, we used climate change scenarios from Worldclim (Hijmans et al., 2005). The data was calculated from future climate projection of General Circulation Models (GCM) of the Coupled Model Intercomparison Project Phase 5 (CMIP5). Base on the study conducted by McSweeney et al. (2014), which evaluated the suitability of different GCMs to predict the Southeast Asia's climate, we selected the three best available GCMs (ACCESS1 - 0; GFDL -

CM3 and MPI - ESM - LR), which was then run under two different greenhouse gas concentration trajectories (RCP4.5 and RCO8.5) (Representative Concentration Pathways). RCP4.5 is an intermediate emission scenario, which is developed by Pacific Northwest National Laboratory in the US. RCP8.5 is a high emission scenario and it is developed by the International Institute for Applied System Analysis in Austria.

III. RESULTS AND DISCUSSION

3.1. Predicting the suitable distribution of SYCCG at the present

The AUC values were higher than 0.92 for all climate scenarios. Therefore, this model can be used to predict the potential distribution of SYCCG. The projection of this model indicated the SYCCG's suitable distribution range lies in the Dak Lak, Dak Nong, Lam Dong, Dong Nai, and Binh Phuoc provinces (Vietnam) and Mundulkiri (Cambodia). Past distribution of this gibbon species covered the Southern Central Highland region and a part of Southeastern region of Vietnam and the Eastern region of Cambodia (Van Ngoc Thinh et al., 2010; Rawson et al., 2011). Therefore, the distribution was generated by MaxEnt is congruent with our understaning on the species distribution.

The potential distribution of SYCCG can be divided into two sections. The first section lies in the Da Lat plateau withelevation ranges from 1,200 - 2,200 m als. The main habitat in this area is broad-leaved evergreen. The second section lies in the Binh Phuoc, Dong Nai province (Vietnam) and Muldokiri (Cambodia). The topology of this area is quite flat. There are two separate seasons in the region: dry and rain seasons. Arcording Dao Van Tien (1983), this is the suitable habitat for gibbon species (Rawson et al., 2011).

At present, the total of suitable area for the species is approximately 52,527.92 km^2, including: highly suitable (11,781.09 km^2), moderately suitable (23,184.30 km^2), and low suitable (17,562.53 km^2) (Fig. 1).

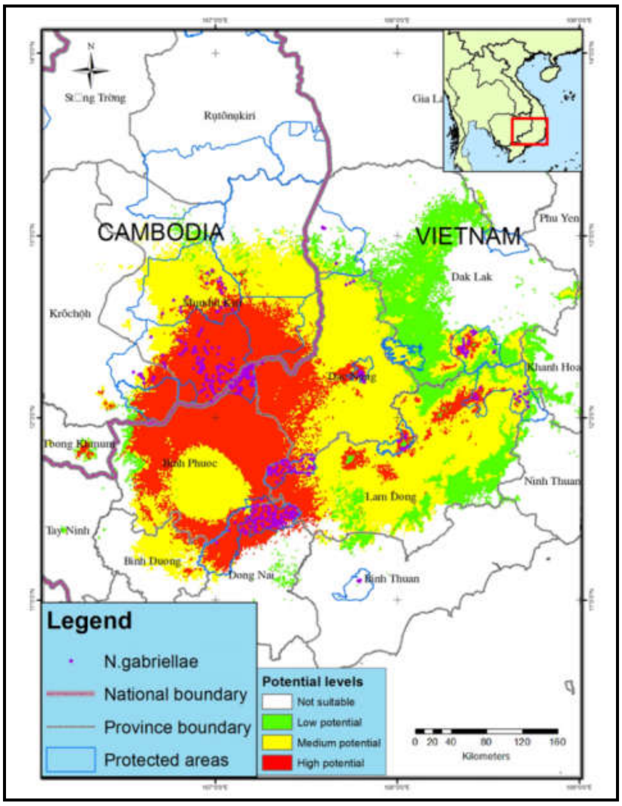
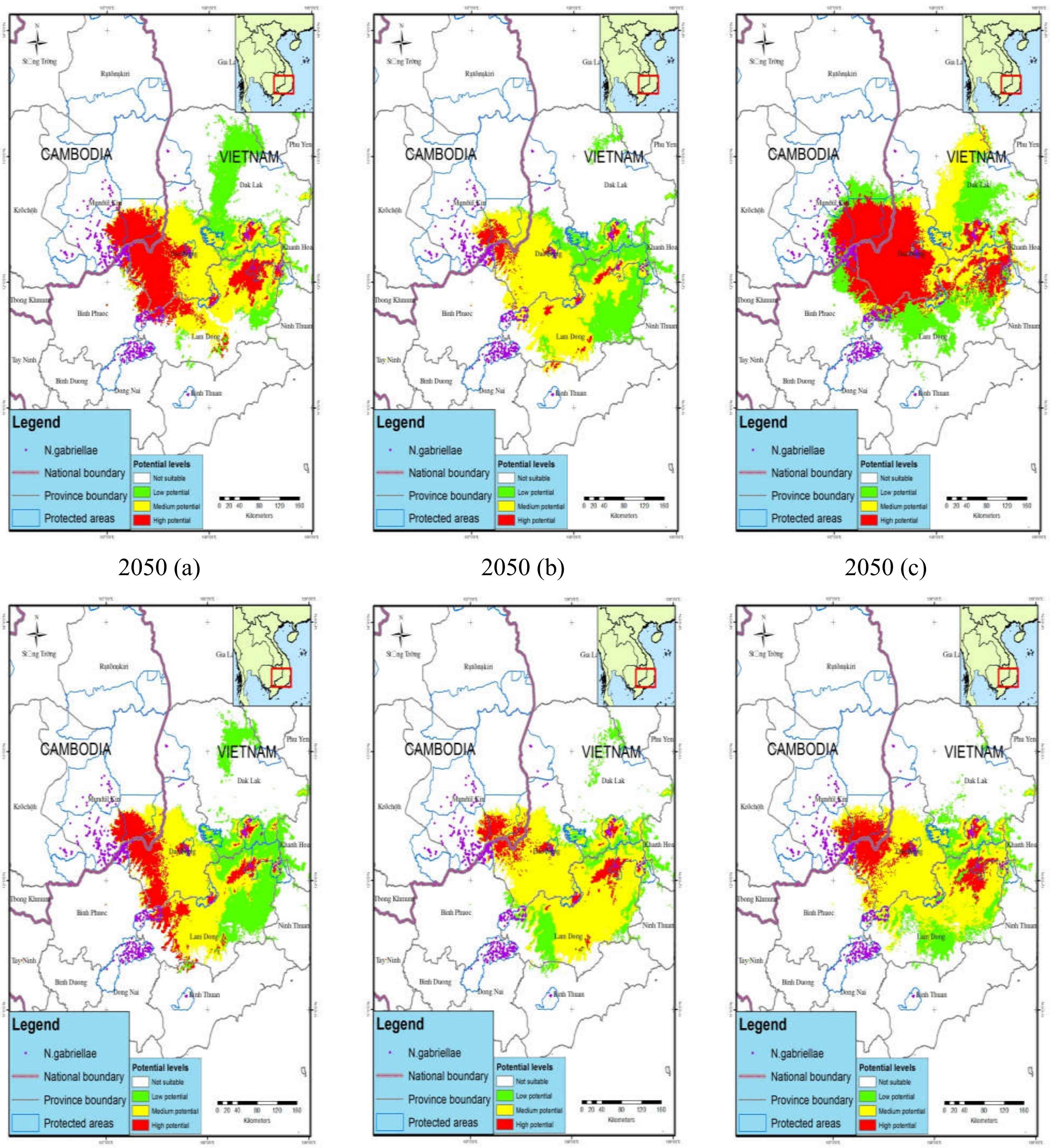


Figure 1. The present potential distribution of N. gabriellae generated by MaxEnt

3.2. The shifts of distribution of SYCCG under climate change scenarios

The extent of SYCCG distribution decreased much under RCP4.5 and RCP8.5 senerios. In addition, while the larges in the current distribution range become unsuitable, the species distribution range did not extend to new areas in the future. The suitable area shrinked toward the center and mountainous areas (Fig. 2, 3).

ACCESS1 - 0 | **GFDL - CM3** | **MPI - ESM - LR**



2050 (a) | 2050 (b) | 2050 (c)

2070 (d) | 2070 (e) | 2070 (f)

Figure 2. The potential distribution of SYCCG under RCP4.5

ACCESS1 - 0 **GFDL - CM3** **MPI - ESM - LR**

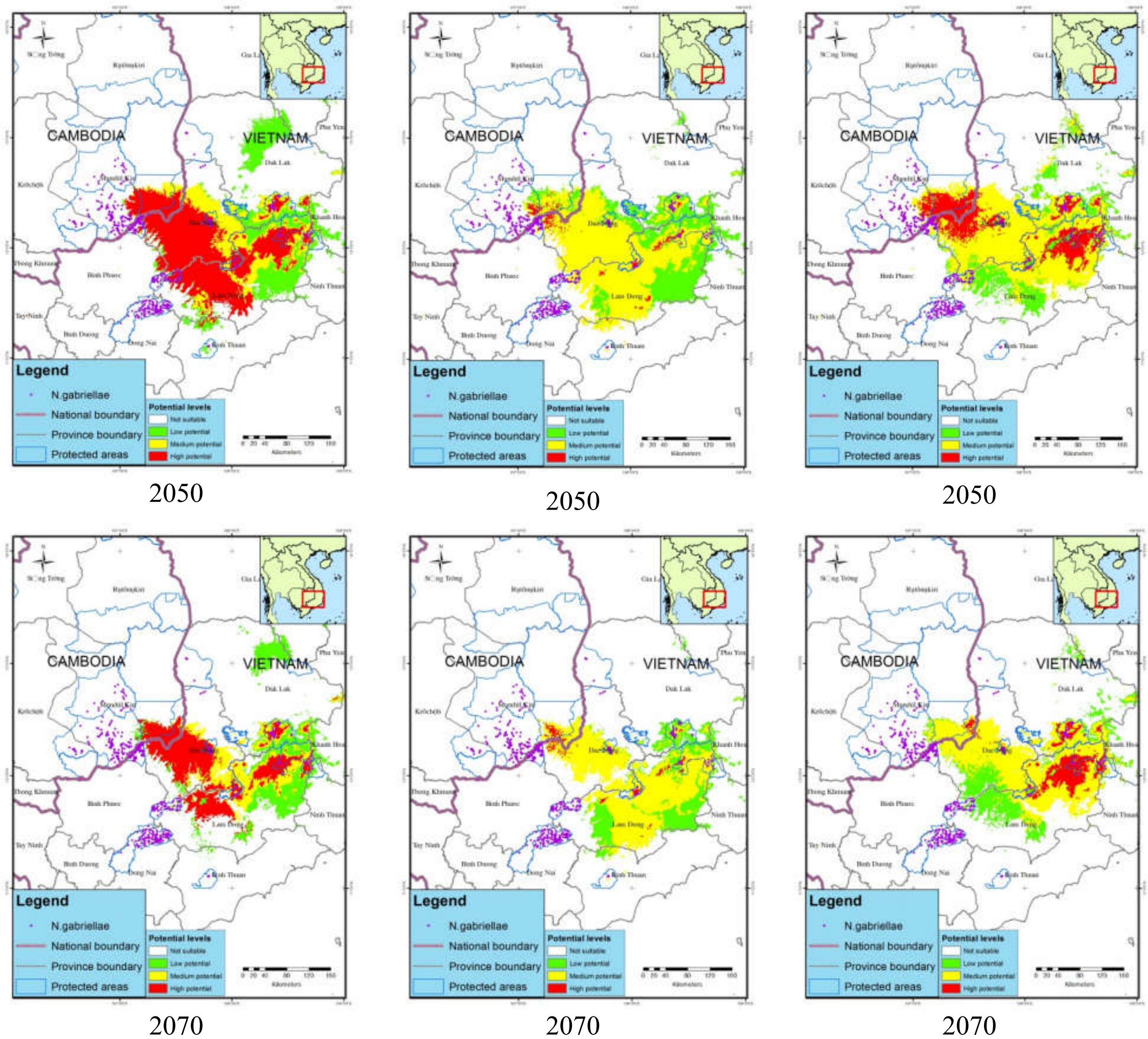


Figure 3. The potential distribution of SYCCG under RCP8.5

Under RCP4.5 scenario, on average the distribution range reducedby about 60.64% in 2050 and 64.23% in 2070. Under RCP8.5 scenario, the species lost 62.77% and 72.83% it's distribution range in 2050 and 2070, respectively (Table 2).

Table 2. The change of potential distribution of SYCCG area under the impact of climate change

Area: km²

Model	RCP	2050			2070		
		Area	Change	%	Area	Change	%
Present		*52,527.92*			*52,527.92*		
ACCESS1-0	4.5	21,826.00	-30,701.92	-58.45	19,999.52	-32,528.40	-61.93
GFDL-CM3	4.5	18,758.27	-33,769.65	-64.29	17,492.45	-35,035.47	-66.70
MPI_ESM	4.5	21,433.69	-31,094.23	-59.20	18,868.09	-33,659.83	-64.08
ACCESS1-0	8.5	23,533.99	-28,993.93	-55.20	11,421.28	-41,106.64	-78.26
GFDL-CM3	8.5	17,511.23	-35,016.69	-66.66	18,976.46	-33,551.46	-63.87
MPI_ESM	8.5	17,628.28	-34,899.64	-66.44	12,422.67	-40,105.25	-76.35

The General Circulation Models (GCM) GFDL-CM3 is the most influential model to the distribution of this SYCCG. Under RCP4.5, the estimated loss of suitable area was 46.29% in 2050 and roughly 66.70% in 2070. Furthermore, the highly suitable distribution dropped considerably to less than 1,000 km^2 in 2070 (Figure 5). Regarding RCP8.5, the potential distribution of SYVVG was most affected also by GFDL-CM3 (35,016.69 km^2) in 2050. By contrast, ACCESS1-0 was the best model. It was predicted that 41,106.64 km^2 current suitable area can be lost by climate change.

RCP8.5 had more impacts on the suitable distribution of SYCCG than RCP4.5. In addition, the model under RCP8.5 projected that the suitable distribution can be severely fragmented and was divided in to two separate sections. The first section was in the South of Dak Lak province and the North of Lam Dong province. This area had the largest natural forest in Vietnam, including: Chu Yang Sin NP, Bidoup - Nui Ba NP and Phuoc Binh NP. Furthemore, this area can be connected with Ta Dung NR to form a biodiversity corridor (Vu Tien Thinh, 2014). The other section is in the West of Dak Nong Province. This area connects with the East of Muldukiri Province, Cambodia, in which the largest SYCCG population was found (Rawson et al., 2011).

Climate change can have impacts on the distribution a variety of species. However, an endemic species or narrow distribution species are more likely to be vulnerable. Thus, their future distribution was predicted to decerease dramatically than that of species with larger distribution range (Levisky et al., 2007). SYCCG is an endemic and restricted-range primate species of Indochina. Gibbons prefer to live in cool climate area and predominately feeds on plants. Therefore, their distribution depends on the types and quality of the forest cover (Pham Nhat, 2002). Global warming can also affect the distribution of vegettation (IPCC, 2013; Virginia et al., 2001). Therefore, the distribution of this gibbon can also be affected considerably by climate change throught the change of forest ecosystems. However, in this study, we restricted our invironemtal variables to only climatic factors.

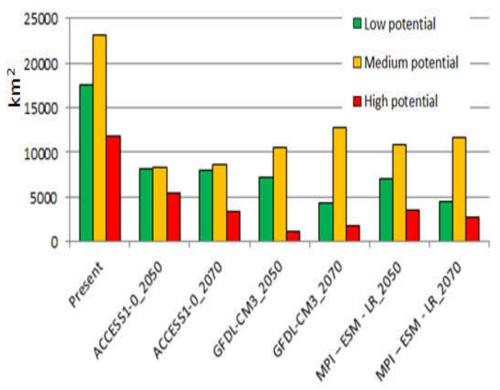


Figure 4. The extent of suitable distribution of SYCCG under RCP 4.5

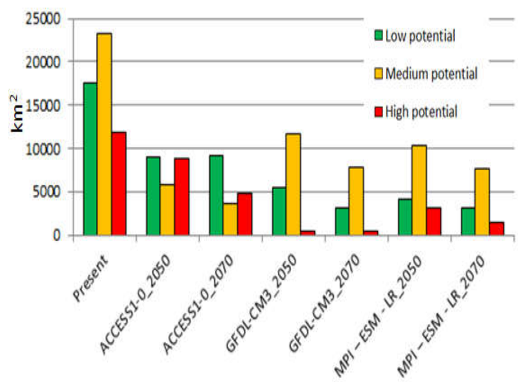


Figure 5. The extent of suitable distribution levels of SYCCG under RCP 8.5

3.3. The pritority protected areas for Southern yeallow-cheeked gibbon

The modelled distribution of SYCCG decreased significantly, especially within protected areas. Six protected areas were considered high prority, including: Chu Yang Sin NP, Bidoup - Nui Ba NP, Ta Dung NR, Nam Kar NR, Nam Nung NR and Pnom Namlear Wildlife Sanctuary (Table 3).

Table 3. The pritority protected areas for Southern yeallow-cheeked gibbon under climate change context

No	Protected areas	Total point	Priority level	No	Protected areas	Total point	Priority level
1	Bidoup - Nui Ba NP	65	High	10	Seima Protected Forest	19	Low
2	Chu Yang Sin NP	64	High	11	Mundulkiri Protected Forest	18	Low
3	Ta Dung NR	63	High	12	Nam Cat Tien (Cat Tien NP)	17	Low
4	Nam Nung NR	59	High	13	Dong Nai C & NR	17	Low
5	Nam Kar NR	50	High	14	Phnom Prich Wildlife Sanctuary	17	Low
6	Pnom Namlear Wildlife Sanctuary	50	High	15	Yok Don NP	15	Low
7	Bu Gia Map NP	31	Medium	16	Easo NR	13	Low
8	Phuoc Binh NP	29	Medium	17	Nui Ong NR	13	Low
9	Cat Loc (Cat Tien NP)	24	Medium	18	Snoul Wildlife Sanctuary	13	Low

The priorty rangking for long-term conservation of SYCCG is important for directing conservation effort to save this species. Priority areas are less affected by climate change. Additionally, these areas contain the large population of SYCCG, for example: Chu Yang Sin NP (166 groups, Vu Tien Thinh et al., 2016), Bidoup - Nui Ba (at least 25 groups, Rawson et al., 2011), Nam Nung NR (at least 11 groups, Rawson et al., 2011). Soe protected areas are holding a large populaiton of SYCCG, such as Cat Tien NP (149 groups), Bu Gia Map NP (176 groups, Rawson et al., 2011), Seima protected forest (432 - 832 groups, Pollard et al., 2007), Phnom Prich Wildlife Sanctuary (149 groups, Channa and Gray, 2009), however, environment factors in these protected areas were predicted to be less suitable with SYCCG.

IV. CONCLUSIONS

The MaxEnt software generated the potential distribution of SYCCG using occurence data and environment variables. The current potential distribution area covers 52,527.92 km^2 in the South of Central Highland, Southeastern region (Vietnam) and Southeastern region of Cambodia.

The model predicted that the future potential distribution of SYCCG was afftected by climate change under RCP4.5 and RCP8.5 scenarios. While large areas in the species distribution range will potentially become unsuitale in the future, no new areas for this species are added to it's distribution range. SYCCG The species distribution range will shrink toward the center and mountainous areas.

High priority areas for long-term conservation of SYCCG in climate change context include Chu Yang Sin NP, Bidoup - Nui Ba NP, Ta Dung NR, Nam Kar NR, Nam Nung, NR and Pnom Namlear Wildlife Sanctuary.

REFERENCES

1. Cat Tien National Park (2004). *Assessing the status of Yellow-cheeked crested Gibbon and raising the awareness of local people using educational activities*. Report of Cat Tien National Park.

2. Dong Thanh Hai, Do Quang Huy, Vu Tien Thinh, Nguyen Van Huy, Bui Hung Trinh, Nguyen Trong Toan, Pham Ngoc Diep (2011). *Assessing biodieversity of Nam Nung NR, Dak Nong province*. Technical report of Vietnam National University of Forestry and Nam Nung NR.

3. Elith, J. (2000). *Quantitative methods for modeling species habitat: Comparative performance and an application to Australian plants*. - In: Ferson, S., Burgman, M., editors. Quantitative methods for conservation biology, Springer, New York.

4. Estrada, A., Garber, P. A., Rylands, A. B., Roos, C., Fernandez-Duque, E., Di Fiore, A., Li, B. (2017). Impending extinction crisis of the world's primates: Why primates matter. *Science Advances*, 3(1): e1600946. http://doi.org/10.1126/sciadv.1600946.

5. Geissmann, T., Dang, N. X., Lormée, N., & Momberg, F. (2000). *Vietnam primate conservation status review 2000. Part 1: gibbons*. Fauna & Flora International, Indochina Programme, Hanoi, Vietnam.

6. Geissmann, T., Manh Ha, N., Rawson, B., Timmins, R., Traeholt, C. & Walston, J. (2008). *Nomascus gabriellae*. The IUCN Red List of Threatened Species 2008:e.T39776A10265736. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T39776A10265736.en. Downloaded on 12 January 2016.

7. Gouveia, S. F., Souza-Alves, J. P., Rattis, L., Dobrovolski, R., Jerusalinsky, L., Beltrão-Mendes, R., & Ferrari, S. F. (2016). Climate and land use changes will degrade the configuration of the landscape for titi monkeys in eastern Brazil. *Glob Change Biol*, 22: 2003-2012. doi:10.1111/gcb.13162.

8. Hijmans, R.J., Cameron S.E., Parra, J.L., Jones P.G., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology,* 25: 1965-1978.

9. Hoang Minh Duc (2010). *Conservation status of the black-shanked douc (Pygathrix nigripes) and other primates in Ninh Thuan and Binh Thuan Provinces, Vietnam.* Technical report to Center for Biodiversity and Development and SeaWorld and Busch Garden Conservation Fund, Ho Chi Minh City, Vietnam.

10. Hoang Minh Duc, Tran Van Bang & Vu Long (2010). *Population status of the yellow-cheeked crested gibbon (Nomascus gabriellae) in Ta Dung Nature Reserve, Dak Nong Province, Vietnam*. Fauna & Flora International.

11. Hoang Minh Duc, Tran Van Bang, Vu Long & Nguyen Thi Tien (2010). *Primate monitoring in Bu Gia Map National Park, Binh Phuoc Province, Vietnam.* Center for Biodiversity and Development, Ho Chi Minh City, Vietnam.

12. IPCC (2013). Summary for Policymakers. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., Qin, D., Plattner, G. K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V. & Midgley, P.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

13. Levinsky, I., Skov, F., Svenning, J. C., & Rahbek, C. (2007). Potential impacts of climate change on the distributions and diversity patterns of European mammals. *Biodiversity and Conservation*, 16(13): 3803-3816. DOI: 10.1007/s10531-007-9181-7.

14. McSweeney, C. F., Jone, R. G., Lee, R. W., & Rowell, D. P (2015). Selecting CMIP5 GCMs for downscaling over multiple regions. *Clim Dyn*, 44: 3237-3260. DOI 10.1007/s00382-014-2418-8.

15. Nadler, T. & Brockman, D. (2014). *Primates of Vietnam.* Endangered Primate Rescue Center, Cuc Phuong National Park, Vietnam.

16. Ngo Van Tri (2003). *Surveys primate species in Yok Don National Park.* Report of Yok Don NP.

17. Nguyen Manh Ha, Nguyen Hoang Hao, Tran Duc Dung, Nguyen Manh Diep, & Pham Van Nong (2010). *Report of yellow-cheeked crested gibbon (Nomascus gabriellae) survey in Dong Nai Nature Reserve, Dong Nai province, Vietnam.* Fauna & Flora International/Conservation International, Hanoi, Vietnam.

18. Pham Nhat (2002). *Primates of Vietnam*. Agricultural publisher, Ha Noi, Vietnam.

19. Channa P. & Gray, T. (2009). *The status and habitat of yellow-cheeked crested gibbon (Nomascus gabriellae) in Phnom Prich Wildlife Sanctuary, Mondulkir*i. WWF Greater Mekong Programme, Phnom Penh, Cambodia.

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

21. Pollard, E., Clements, T., Hor N. M., Ko S., & Rawson, B. (2007). *Status and conservation of globally threatened primates in the Seima Biodiversity conservation area, Cambodia.* Project report.

22. Rawson, B. M, Insua-Cao, P., Nguyen Manh Ha, Van Ngoc Thinh, Hoang Minh Duc, Mahood, S., Geissmann, T., & Roos, C., (2011). *The Conservation Status of Gibbons in Vietnam*. Fauna & Flora International/Conservation International, Hanoi, Vietnam.

23. Root, T. L & Schneider, S.H. (2002). *Climate change: Overview and Implications for Wildlife, from Wildlife responses to climate change: North American case studies.* Washington D.C.: Island Press.

24. Sesink-Clee P. R., Abwe E. E., Ambahe R., Anthony N. M., Fotso R., Locatelli S., Maisels F., Mitchell M. W., Morgan B. J., Pokempner A., & Gonder M. K. (2015). Chimpanzee population structure in Cameroon and Nigeria is associated with habitat variation that may be lost under climate change. *BMC Evolutionary Biology*, 15, Art. No.: 2.

25. Van Ngoc Thinh, Mootnick, A. R., Vu Ngoc Thanh, Nadler T., & Roos, C. (2010). A new species of crested gibbon, from the Central Annamite Mountain Range. *Vietnamese Journal of Primatology,* 4:1-12.

26. Vu Tien Thinh (2014). Proposing green corridors to conserve biodiversity of southern Vietnam in the context of climate change. *Journal of Forest and Environment*, 65: 24-31.

27. Vu Tien Thinh, Tran Van Dung, Giang Trong Toan, Kieu Tuyet Nga, Nguyen Huu Van, Nguyen Dac Manh, Nguyen Chi Thanh, Paul Doherty (2016). A mark-recapture population size estimation of southern yellow-cheeked crested gibbon Nomascus gabriellae (Thomas, 1909) in Chu Yang Sin national park, vietnam. *Asian Primates Journal,* 6(1): 2016.

28. Wiederholt, R., & Post, E. (2010). Tropical warming and the dynamics of endangered primates. *Biology Letters*, 6(2): 257-260. http://doi.org/10.1098/rsbl.2009.0710.

ỨNG DỤNG MÔ HÌNH MAXENT ĐỂ ĐÁNH GIÁ ẢNH HƯỞNG CỦA BIẾN ĐỔI KHÍ HẬU ĐẾN VÙNG PHÂN BỐ CỦA LOÀI VƯỢN MÁ VÀNG PHÍA NAM (*Nomascus gabriellae*)

Vũ Tiến Thịnh[1], Trần Văn Dũng[2], Lưu Quang Vinh[3], Tạ Tuyết Nga[4]

[1,2,3,4]*Trường Đại học Lâm nghiệp*

TÓM TẮT

Biến đổi khí hậu đang có nhiều tác động tiêu cực tới các loài động vật hoang dã, trong đó có ảnh hưởng đến vùng phân bố của chúng. Các loài có vùng phân bố hẹp thường bị ảnh hưởng bởi biến đổi khí hậu nặng nề hơn so với các loài có vùng phân bố rộng. Trong nghiên cứu này, chúng tôi đã sử dụng mô hình ổ sinh thái (phần mềm MaxEnt), cùng với dữ liệu về sự có mặt của loài và các biến khí hậu để đánh giá ảnh hưởng của biến đổi khí hậu đến loài Vượn má vàng phía Nam (*Nomascus gabriellae*), một loài linh trưởng đặc hữu, quý hiếm của Việt Nam và Campuchia. Các dữ liệu về khí hậu được sử dụng bao gồm thời điểm hiện tại và hai thời điểm trong tương lai (2050 và 2070). Hai kịch bản khí hậu RCP4.5 và RCP8.5 cùng với ba mô hình khí hậu ACCESS1 - 0; GFDL - CM3 và MPI - ESM - LR được sử dụng để chạy mô hình. Kết quả cho thấy, vùng phân bố của loài Vượn má vàng phía Nam bị giảm mạnh bởi biến đổi khí hậu. Nhiều vùng phân bố thích hợp bị biến mất, đặc biệt là các diện tích có mức độ thích hợp cao và rất cao. Các vùng phân bố thích hợp còn lại có xu hướng dịch chuyển về phía trung tâm và các khu vực có núi cao hơn. Đồng thời, chúng tôi cũng đánh giá mức độ ưu tiên của các khu rừng đặc dụng trong bảo tồn loài vượn dưới ảnh hưởng của Biến đổi khí hậu.

Từ khóa: Biến đổi khí hậu, Maxent, Nomascus, ổ sinh thái, Vượn.

Received : 07/01/2018
Revised : 27/3/2018
Accepted : 03/4/2018