Developing capacity and informing priorities for ape conservation under climate change in Vietnam

Project summary report with recommendations for policy and management

American Museum of Natural History

Center for Biodiversity and Conservation

Suggested Citation: Blair, ME, Nguyen, TA, López-Lozano, D, Gazagne, E, and Le, MD. 2025. Developing capacity and informing priorities for ape conservation under climate change in Vietnam: Project summary report with recommendations for policy and management. Center for Biodiversity and Conservation of the American Museum of Natural History, New York, NY. 11pp.

This project benefitted from the support of the Arcus Foundation.

PHOTO CREDITS

COVER *Nomascus gabriellae* Hoang Thach/CBC-AMNH
PAGE 2 Nguyen Tuan Anh
PAGE 5 *N. nasutus* Nguyen Duc Tho/Fauna & Flora
PAGE 10 *N. annamensis* Nguyen Tuan Anh

PROJECT PARTNERS

University of Science, Vietnam National University, Hanoi (VNU)
Central Institute for Natural Resources and Environmental Studies, VNU
Fauna and Flora -Vietnam
GreenViet
Da Nang University
Frankfurt Zoological Society
Vietnam Administration of Forestry
Vietnam National University of Forestry, Ministry of Agriculture and Environment
Nature and Biodiversity Conservation Agency, Ministry of Agriculture and Environment
Southern Institute of Ecology

CONTRIBUTORS

Hoang Van Chuong (GreenViet), Tran Ngoc Son (Danang University), Tran Van Bang (SIE), Eva Gazagne (ULiège), Ha Thang Long, Nguyen Ai Tam and Nguyen Van Tay (FZS), Vu Tien Thinh and Tran Van Dung (VNUF), Camille Coudrat (Anoulak), Nguyen Duc Tho (FFI-Vietnam), Tran Dang Hieu (VietNature), Nguyen Dinh Duy (IEBR), Nguyen Van Thanh (CRES & IZW), Nguyen Manh Ha (CCD), Trung La (CCD), Trinh Dinh Hoang (FFI), Russell Gray (SVW), Nguyen Tai Thang (ATP), Petra Schill (GIZ), Herbert Covert (U. Colorado at Boulder).

Vietnam: Biodiversity, Apes, and Climate Change

Vietnam is well known for having unique and high levels of biodiversity, supporting a wide range of habitats due to extensive climatic and topographic variation. Hundreds of new species of vertebrates and plants have been described in Vietnam since 1992. Vietnam ranks among the top global priorities for primate conservation, hosting a high number of endemic and threatened species. It is also a key country for ape conservation: of the seven *Nomascus* gibbons, all but one species are found in Vietnam. All six are severely threatened by illegal hunting and habitat destruction, and are listed as Endangered or Critically Endangered in the IUCN Red List and included in the Vietnam's national protected species list (Decree 64/2019). The potential effects of climate change on these species and their habitats are poorly known. This project aimed to fill that gap by producing species-specific climate projections and informing climate-resilient conservation planning.

How is climate change expected to alter the region?

Global climate change is expected to significantly alter the climate in Southeast Asia, with a wetter wet season, a drier dry season, an increased rainfall variability, along with overall rising temperatures. These changes will likely intensify existing pressures on both human and nonhuman primate communities. More detailed information on the potential impacts of climate change is critical for forward-looking adaptation and mitigation strategies in ape conservation.

Anticipated changes in habitats and ecosystems due to climate change will result in shifts in species' distributions and increase the risk of both local and global extinctions, especially for species already experiencing population declines, such as all six of the *Nomascus* gibbon species with distributions in Vietnam. Given this as well as additional pressing threats to current habitats, national primate and gibbon conservation action plans are increasingly focused on population re-establishment and recovery efforts. These efforts will benefit from the integration of climate change projections. Vietnam's National Biodiversity Strategies and Action Plans and National Action Plan for Primate Conservation call for a systematic assessment of climate change threats to key species, with a priority for range-restricted and endangered species like the gibbons. Such assessments will inform recommendations for strategic management actions within Protected Area and corridor planning processes.

How can potential climate change impacts be assessed?

Species Distribution Models (SDMs) are widely used to predict the magnitude of potential species distribution shifts in response to climate change and inform conservation planning. Incorporating expert knowledge is considered a best practice when applying SDMs, especially for rare and endangered species with limited data. For the greatest impact on conservation decision-making, SDMs should be developed collaboratively from the outset with all stakeholders to whom the model results are relevant.

This report summarizes the results of a project that aimed to support evidence-based conservation planning for endangered ape species under climate change, with a focus on gibbons in Vietnam. Specifically, the project team produced high-resolution, expert-informed climate change projections for all gibbon species with distributions in Vietnam. The report also provides model-informed recommendations from experts and project contributors for policy and management actions to guide forward-thinking conservation strategies for these threatened apes in the face of imminent change.

Results Summary

We conducted expert and stakeholder consultations to gather and verify occurrence data for Vietnam's gibbons, resulting in the most comprehensive dataset to date. Specifically, we gathered all publicly available gibbon distribution information using three main sources: published information (scientific papers and field reports), field observations shared by experts, stakeholders and partners, and our own field data from project-supported fieldwork. This resulted in final datasets of 374 localities for *Nomascus annamensis*, 271 for *N. nasutus*, 646 for *N. gabriellae*, 556 for *N. siki*, 134 for *N. leucogenys*, and 148 for *N. concolor*.

We then optimized SDMs and projected high-resolution, expert-informed climate change projections for all the gibbons of Vietnam. The future climate projections used in this study come from five global climate models (CMCC-ESM2, MRI-ESM2-0, CanESM5, MPI-ESM1-2-HR, and UKESM1-0-LL), which are developed by leading climate research centers worldwide. These models simulate different aspects of the Earth's climate system at varying spatial resolutions and with differing representations of atmospheric, oceanic, and land surface processes. Using multiple models helps capture uncertainties and provides a more comprehensive picture of potential future climates in Vietnam. The resulting models show high predictive ability within an acceptable range of uncertainty following SDM best practice standards for biodiversity assessments. All species are projected to experience an overall reduction in suitable habitat, including within existing conservation areas (see Table 1 and following figures). Among them, *N. nasutus* is predicted to lose the greatest extent of suitable area on average, followed by *N. leucogenys* and *N. gabriellae*.

Specifically, the projections for *N. gabriellae* range from a 12-75% loss of suitable habitat area by 2060 to 9-94% loss by 2100. For *N. annamensis* we project a 15-54% loss by 2060 to a 12-58% loss by 2100. For *N. siki* we project a 12-78% loss by 2060 to a 1-89% loss by 2080. For *N. leucogenys*, we project a 37-89% loss by 2060 to a 17-97% loss by 2100. For *N. concolor**, we project a 36-74% loss by 2060 to a 43-86% loss by 2100. Finally, for *N. nasutus*, we project a 35-87% loss by 2060 to a 56-91% loss by 2100 (also see Trinh-Dinh et al. 2022).

Climate variables related to seasonality emerged as important predictors in the optimal models for each species. This aligns with expert observations that shifts in rainy and dry seasons strongly influence the recording of the presence or absence of gibbon groups. While some species are predicted to experience geographic shifts in their suitable habitat, most are projected to undergo contractions within their current suitable habitat rather than expand into new areas. Several species may move upward in elevation or move inland to find climatically suitable conditions, potentially crossing national borders or moving between currently disconnected protected areas.

These future projections consider suitable climatic habitat only, and do not account for dispersal limitations, interactions among species, or other factors such as changes in human land use. As such, they may overestimate potential range shifts but also are likely to underestimate overall habitat loss. Importantly, these models were developed collaboratively with gibbon experts and conservation stakeholders, who vetted model outputs and identified key data and knowledge gaps to address in future work. Their contributions also provide essential context and expertise to inform the following policy and management interpretations of the models.

*Note that this result contradicts a 2021 study of *N. concolor* (Yang et al. 2021) that predicted a potential increase in range under climate change, as cited in the 2023 status update. The current analysis reported here utilized a more comprehensive dataset.

Policy, Planning, and Management Recommendations

Under the Vietnam National Biodiversity Strategy and National Conservation Program for Endangered, Rare, Precious, and Prioritized Vertebrates to 2030, Vision to 2050, the impacts of climate change on biodiversity and nationally protected species, which comprise all six gibbons, should be assessed to determine priority ecosystems and habitats for implementing climate change mitigation measures.

The results of this project provide critical insights to inform planned species' habitat recovery and population re-establishment efforts, as well as the design of species and biodiversity conservation corridors at regional and national scales in Vietnam and neighboring countries. In particular, these results can help prioritize the connectivity of key habitats outside of existing protected areas.

Experts emphasized that the findings should guide climate-informed releases of captive gibbons back into the wild to reinforce natural populations, especially for species with limited distribution data. Immediate plans to implement such releases are underway, led by at least two Vietnamese conservation NGOs.

These results also support national targets, including improving the conservation of priority species and assessing the impacts of climate change on biodiversity, as outlined in Vietnam's National Biodiversity Strategies and Action Plans and Vietnam's Primate Conservation Action Plan.

The ensembled future projections suggest that many existing protected areas will likely remain suitable for several species (see figures below). However, there are risks of local extirpation, especially in smaller protected areas that are predicted to lose suitable habitat. For example, we are predicting a severe decrease in suitable areas for *N. gabriellae* within conservation areas in eastern Cambodia by 2100. Conversely, several areas between current protected zones maintain suitability into the future, representing promising candidates for conservation corridors or for targeted habitat recovery and population re-establishment efforts. Importantly, additional studies would be needed to inform such efforts, particularly to account for dispersal limitations, species interactions, and human land use changes.

Experts also highlighted key gaps in input data and taxonomic uncertainties, especially in regions like central Vietnam where distinguishing between northern and southern white-cheeked gibbons remains challenging. Fine-tuned SDM results, developed after workshops with expert input, recommend prioritizing these areas for future field surveys to address these current knowledge shortcomings. Furthermore, participants discussed best practices for communicating uncertainties and model caveats when applying model predictions to management decisions. For example, they underscored the importance of corroborating model outputs with additional datasets and recommended using overall model trends across species, rather than relying on highly specific, area-based predictions, especially in zones of taxonomic uncertainty.

Other relevant topics meriting further research, though beyond the scope of this project, include inconsistencies in survey methodologies, the need for both morphological and molecular studies to resolve persistent taxonomic confusion, the contributions of unpublished or unshared survey information, effects of climate change on behavioral ecology, and the implementation of long-term monitoring programs.

In addition to developing collaborative, expert-informed models and recommendations, this project aimed to strengthen the capacity of national and regional conservation and land-use planning agency staff to assess and address climate change impacts on range-restricted endangered species, particularly gibbons. To this end, a series of workshops and trainings were conducted to support researchers, conservationists, protected area managers, and forestry staff to integrate climate change considerations into their conservation planning. Participants were trained in using MaxEnt, a popular SDM approach that can produce robust results even for rare, data-limited endangered species, to assess the impacts of climate change on their gibbon species of interest. Using the Wallace software platform, which implements MaxEnt, participants learned data processing workflows, including handling gibbon locality data, environmental layers, standard protocols, and best practices for building SDMs for endangered species with small datasets. The training also covered the strengths and limitations of the MaxEnt approach, ensuring participants understood when and how SDMs should be used to inform conservation decisions.

Moving forward, further opportunities should be prioritized to strengthen the capacity of national and regional conservation and land-use planners in spatial conservation planning for climate change impacts on primates and ecosystems. Such initiatives could include expanded training in SDM and other modeling approaches, as well as fostering regional knowledge exchange networks throughout Southeast Asia.

Table 1. Summary of future projected changes in climatically suitable habitat for all six gibbon species in Vietnam.

	2041 – 2060				2061 – 2080				2081 – 2100			
N. concolor	Area (km^2)	Std.Dev. (km^2)	% change	Std.Dev. (%)	Area (km^2)	Std.Dev. (km^2)	% change	Std.Dev. (%)	Area (km^2)	Std.Dev. (km^2)	% change	Std.Dev. (%)
CMCC-ESM2	-175,685	27,969	-40.90	6.51	-256,998	52,102	-59.83	12.13	-292,209	67,265	-68.03	15.66
MRI-ESM2-0	-163,337	54,821	-38.03	12.76	-220,351	73,814	-51.30	17.19	-276,135	83,549	-64.29	19.45
CanESM5	-233,737	56,194	-54.42	13.08	-302,776	82,892	-70.49	19.30	-326,467	98,265	-76.01	22.88
MPI-ESM1-2-HR	-155,947	52,229	-36.31	12.16	-194,904	56,518	-45.38	13.16	-183,624	90,252	-42.75	21.01
UKESM1-0-LL	-316,496	32,739	-73.69	7.62	-349,790	47,809	-81.44	11.13	-368,076	58,922	-85.70	13.72
N. nasutus												
CMCC-ESM2	-39,022	17,417	-47.58	21.24	-60,214	9,236	-73.42	11.26	-60,528	15,694	-73.80	19.14
MRI-ESM2-0	-51,201	11,517	-62.43	14.04	-58,498	19,744	-71.33	24.07	-64,552	19,480	-78.71	23.75
CanESM5	-61,611	11,688	-75.12	14.25	-69,069	13,475	-84.21	16.43	-71,782	13,239	-87.52	16.14
MPI-ESM1-2-HR	-28,782	10,201	-35.09	12.44	-39,500	25,632	-48.16	31.25	-46,436	33,451	-56.62	40.79
UKESM1-0-LL	-71,171	8,753	-86.78	10.67	-74,196	8,729	-90.47	10.64	-74,223	11,761	-90.50	14.34
N. leucogenys												
CMCC-ESM2	-64,731	40,929	-42.51	26.88	-94,463	52,319	-62.04	34.36	-84,040	70,489	-55.20	46.30
MRI-ESM2-0	-114,545	31,402	-75.23	20.62	-120,433	37,583	-79.10	24.68	-142,300	16,707	-93.46	10.97
CanESM5	-107,924	22,657	-70.88	14.88	-128,167	24,752	-84.18	16.26	-133,751	28,571	-87.85	18.77
MPI-ESM1-2-HR	-56,155	37,674	-36.88	24.74	-65,788	35,865	-43.21	23.56	-25,515	53,445	-16.76	35.10
UKESM1-0-LL	-136,344	6,420	-89.55	4.22	-144,630	5,164	-94.99	3.39	-147,375	6,820	-96.80	4.48
N. siki												
CMCC-ESM2	-6,016	5,305	-12.65	11.15	-633	18,252	-1.33	38.37	6,779	33,722	14.25	70.90
MRI-ESM2-0	-36,275	6,740	-76.27	14.17	-37,776	6,912	-79.42	14.53	-38,151	6,946	-80.21	14.60
CanESM5	-18,893	6,798	-39.72	14.29	-28,453	8,494	-59.82	17.86	-29,126	8,345	-61.24	17.55
MPI-ESM1-2-HR	-10,880	17,720	-22.87	37.26	-6,620	14,926	-13.92	31.38	18,238	12,439	38.35	26.15
UKESM1-0-LL	-37,254	3,582	-78.32	7.53	-42,552	2,285	-89.46	4.80	-42,602	4,236	-89.57	8.91
N. annamensis												
CMCC-ESM2	-36,964	16,443	-25.74	11.45	-48,519	16,947	-33.79	11.80	-47,472	23,734	-33.06	16.53
MRI-ESM2-0	-54,947	15,639	-38.26	10.89	-60,602	18,429	-42.20	12.83	-82,583	28,997	-57.51	20.19
CanESM5	-44,340	9,856	-30.88	6.86	-55,355	15,621	-38.55	10.88	-65,246	24,505	-45.44	17.06
MPI-ESM1-2-HR	-22,814	10,645	-15.89	7.41	-22,555	8,050	-15.71	5.61	-17,808	19,079	-12.40	13.29
UKESM1-0-LL	-76,975	14,604	-53.60	10.17	-100,982	27,693	-70.32	19.28	-112,763	35,114	-78.52	24.45
N. gabriellae												
CMCC-ESM2	-38,911	5,710	-49.55	7.27	-59,696	15,246	-76.02	19.41	-53,646	19,116	-68.31	24.34
MRI-ESM2-0	-58,714	12,471	-74.77	15.88	-69,052	10,350	-87.93	13.18	-73,440	8,496	-93.52	10.82
CanESM5	-45,224	10,596	-57.59	13.49	-59,099	17,833	-75.26	22.71	-64,029	21,137	-81.54	26.92
MPI-ESM1-2-HR	-9,824	2,796	-12.51	3.56	-14,474	16,301	-18.43	20.76	-6,947	20,249	-8.85	25.79
UKESM1-0-LL	-54,802	5,124	-69.79	6.52	-65,054	9,937	-82.84	12.65	-68,725	13,390	-87.52	17.05

* Results are presented across five future climate model projections (CMCC-ESM2, MRI-ESM2-0, CanESM5, MPI-ESM1-2-HR, and UKESM1-0-LL) over three future time periods. We also ran all four Shared Socio-economic Pathways or SSP scenarios from the 2023 IPCC 6th assessment report CMPI6: SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5). Individual binary maps (10% omission rate) for each SSP scenario of the same model and the same timeframe were then stacked and combined in an ensemble approach to generate presence probability maps for the species. Future projections are of potentially suitable climatic habitat and do not account for dispersal limitations or species interactions or other factors and thus may overestimate potential shifts and underestimate losses.

Expert-Informed Modeled Projections Under Climate Change

None

From 1 to 4 scenarios

From 5 to 8 scenarios

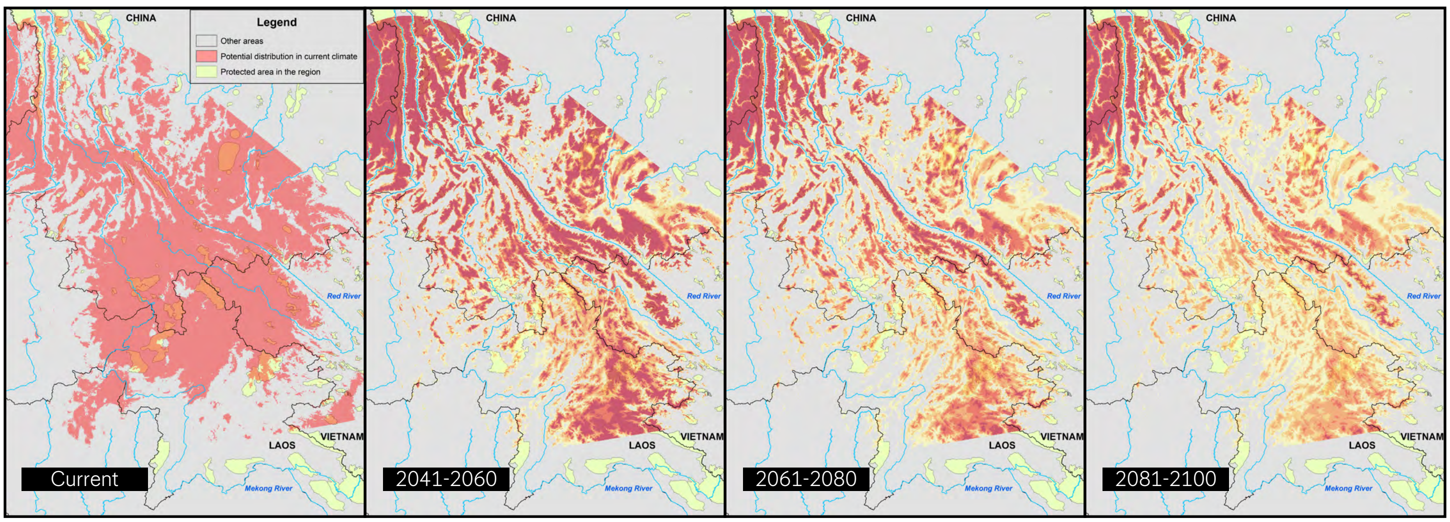
From 9 to 12 scenarios

From 13 to 16 scenarios

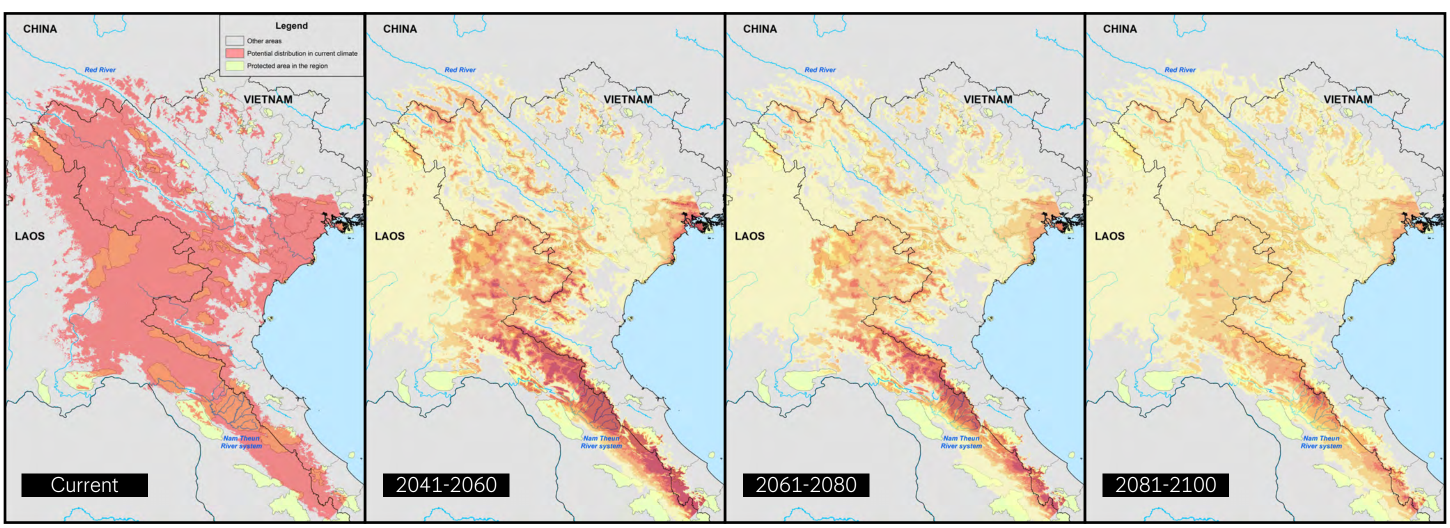
From 17 to 20 scenarios

Protected area in the region

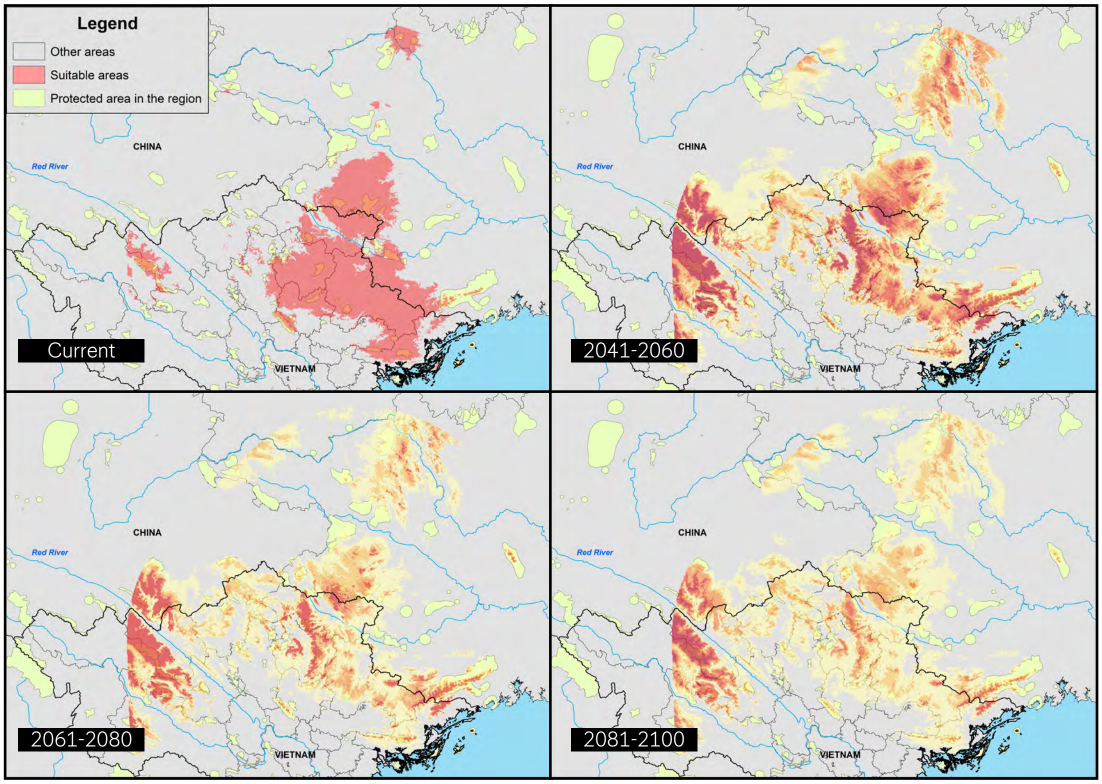
Western black crested gibbon (*Nomascus concolor*)
IUCN Red List Status: CR – Population trend: Decreasing



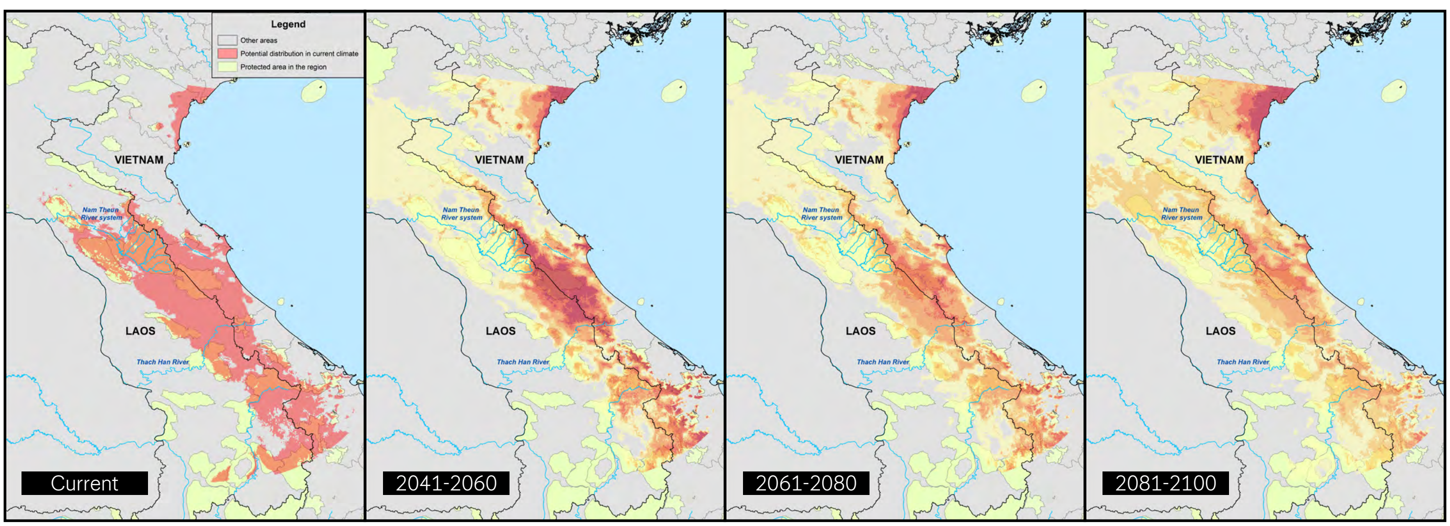
Northern white-cheeked gibbon (*N. leucogenys*)
IUCN Red List Status: CR – Population trend: Decreasing



Eastern black crested gibbon (*N. nasutus*)
IUCN Red List Status: CR – Population trend: Decreasing

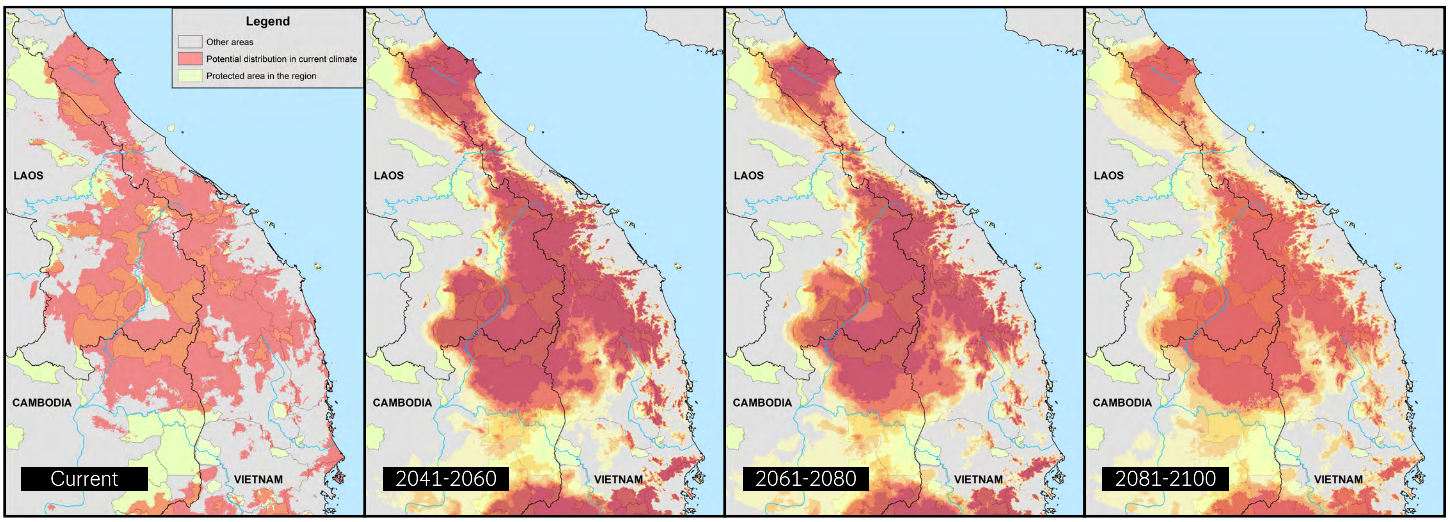


Southern white-cheeked gibbon (*N. siki*)
IUCN Red List Status: CR – Population trend: Decreasing



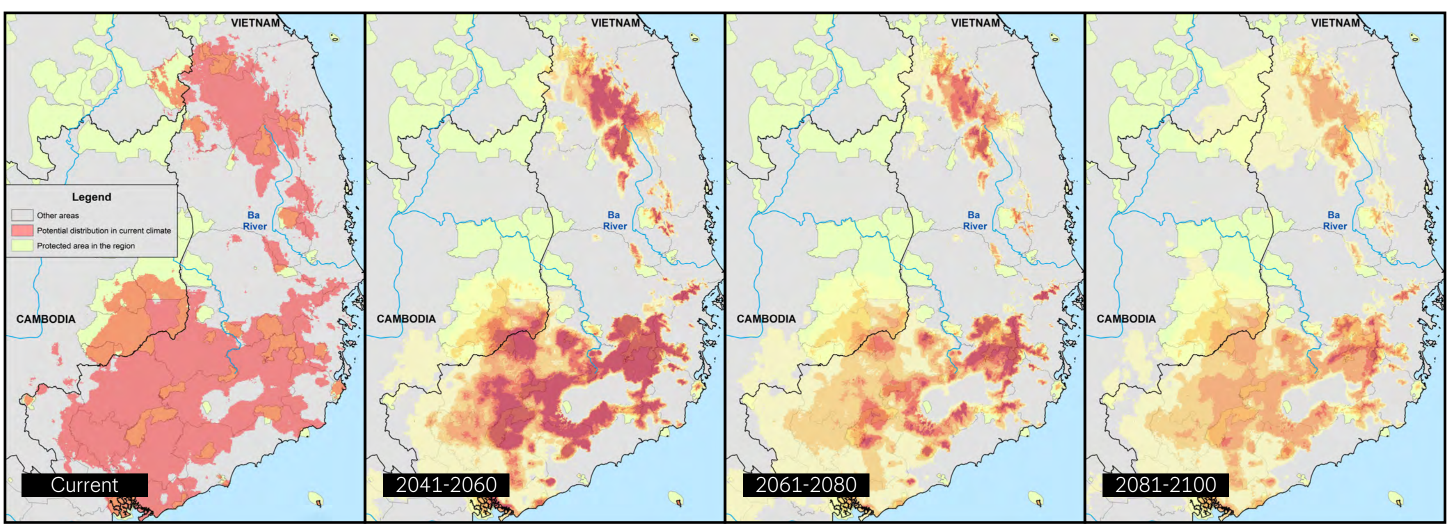
Northern yellow-cheeked gibbon (*N. annamensis*)

IUCN Red List Status: EN – Population trend: Decreasing



Southern yellow-cheeked gibbon (*N. gabriellae*)

IUCN Red List Status: EN – Population trend: Decreasing



DATA SOURCES

Species information: Project partners, contributors, publications referenced below, GBIF, IUCN Red List of Threatened Species.

Environmental data: IUCN World Commission on Protected Areas, Worldclim.org, IPCC

Country and protected area borders: Natural Earth, World Database on Protected Areas, protected area management authorities.

FOR MORE INFORMATION CONTACT

Mary Blair mblair1@amnh.org
Nguyen Tuan Anh tuananhnguyen@hus.edu.vn
Minh Le le.duc.minh@hus.edu.vn

RESOURCES

Additional project information and software tools available at:
https://www.amnh.org/research/center-for-biodiversity-conservation/research-and-conservation/biodiversity-exploration-and-monitoring/evolutionary-biogeography
https://www.amnh.org/research/center-for-biodiversity-conservation/capacity-development/biodiversity-informatics/open-source-software-and-scripts

REFERENCES

Blair, ME, et al. 2022. Species distribution modeling to inform transboundary species conservation and management under climate change: promise and pitfalls. Frontiers of Biogeography, 14(1). http://doi.org/10.21425/F5FBG54662

Chuong Van Hoang, et al. 2018. A review of the distribution of a new gibbon species: The northern yellow-cheeked crested gibbon *Nomascus annamensis*. Primate Conservation 32: 185-191. https://static1.1.sqspcdn.com/static/f/1200343/28066685/1548606957073/PC32_Hoang_Chuong_et_al_Distribution_N_annamensis.pdf?token=oPa52qYHvlsK2s5cyAYP6AzLeAk%3D

Foden, WB, and Young, BE, (eds). 2016. IUCN SSC Guidelines for Assessing Species' Vulnerability to Climate Change. Version 10. Occasional Paper of the IUCN Species Survival Commission No. 59. Cambridge, UK and Gland, Switzerland: IUCN Species Survival Commission. 114pp. https://iucn.org/resources/publication/iucn-ssc-guidelines-assessing-species-vulnerability-climate-change

Hannah, L, et al. 2007. Protected area needs in a changing climate. Frontiers in Ecology and the Environment 5: 131-138. https://doi.org/10.1890/1540-9295(2007)5[131:PANIAC]2.0.CO;2

IPCC. 2023. Climate Change 2023: The Physical Science Basis 6th Assessment Report, Intergovernmental Panel on Climate Change (IPCC), Cambridge, UK, Cambridge University Press. https://doi.org/10.59327/IPCC/AR6-9789291691647.001

Kass, J., et al. 2023. Wallace 2: a shiny app for modeling species niches and distributions redesigned to facilitate expansion via module contributions. Ecography 2023(3): e06547. https://doi.org/10.1111/ecog.06547

Linnell, J, et al. 2016. Border Security Fencing and Wildlife. PLOS Biology 14(6): e1002483. https://doi.org/10.1371/journal.pbio.1002483

Pecl, GT, et al. 2017. Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. Science 355:6332. https://doi.org/10.1126/science.aai9214

Phung, K, et al. 2023. Changes in suitable habitat for the critically endangered Northern white-cheeked gibbon (Nomascus leucogenys) in the Western Nghe An Biosphere Reserve, Vietnam: Implication for conservation. Nature Conservation 51: 167-188. https://doi.org/10.3897/natureconservation.51.90373

Sterling, EJ, et al. 2017. Assessing the evidence for stakeholder engagement in biodiversity conservation. Biological Conservation 209: 159-171. http://dx.doi.org/10.1016/j.biocon.2017.02.008

Tran, D, et al. 2023. A review on the status and modeling of suitable habitats of the southern white-cheeked gibbon. Primates 64: 227- 237. https://doi.org/10.1007/s10329-022-01047-4

Trinh-Dinh, H, et al. 2022. Assessment of climate change impacts on one of the rarest apes on Earth, the Cao Vit Gibbon *Nomascus nasutus*. Frontiers of Biogeography 14(1): e53320. https://doi.org/10.21425/F5FBG53320

Villero, D, et al. 2017. Integrating species distribution modelling into decision-making to inform conservation actions. Biodiversity & Conservation 26: 251-271. https://doi.org/10.1007/s10531-016-1243-2

Wearn, OR, et al. 2023. The Conservation Status of Gibbons in Vietnam: Updated to 2023. Fauna & Flora – Vietnam Programme / IUCN Primate Specialist Group – Section on Small Apes, Hanoi, Vietnam. https://gibbons.asia/resource/the-conservation-status-of-gibbons-in-vietnam-updated-to-2023/

Wearn, OR, et al. 2024. Vocal fingerprinting reveals a substantially smaller global population of the Critically Endangered cao vit gibbon (*Nomascus nasutus*) than previously thought. Scientific Reports 14: 416. https://doi.org/10.1038/s41598-023-50838-2

Yang, L., Shi, K.C., Ma, C., Ren, G.P. & Fan, P.F. (2021) Mechanisms underlying altitudinal and horizontal range contraction: The western black crested gibbon. Journal of Biogeography, 48, 321–331. https://doi.org/10.1111/jbi.13998