The Conservation Status of GIBBONS in VIETNAM: Updated to 2023



Fauna & Flora IUCN Section on Small Apes





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Front cover inset image: Female cao vit gibbon (*Nomascus nasutus*) in the Cao Vit Gibbon Species & Habitat Conservation Area, Cao Bang Province.

Front cover background image: Western black gibbon (*Nomascus concolor*) habitat in Mu Cang Chai Species & Habitat Conservation Area, Yen Bai Province.

Back cover image: Southern yellow-cheeked gibbon (*Nomascus gabriellae*) habitat in Cat Tien National Park (Nam Cat Tien sector), Dong Nai Province.

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A translation of this report in Vietnamese has also been produced and disseminated to local conservation actors and is available upon request.

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Abbreviations used

- CCD Center for Nature Conservation and Development
- EPRC Endangered Primate Rescue Center
- FPD Forest Protection Department
- IPZ Intensive Protection Zone
- IUCN International Union for Conservation of Nature
- NGO Non-governmental Organisation
- NP National Park
- NPA National Protected Area (a protected area designation used in Laos)
- NPAP National Primate Action Plan (for Vietnam)
- NR Nature Reserve
- NTFP Non-timber Forest Product
- PA Protected Area
- PF Protection Forest (typically managed for watershed protection)
- PPC Provincial People's Committee
- PRCF People Resources and Conservation Foundation
- PVA Population Viability Analysis
- SECR Spatially Explicit Capture-recapture (a robust method for estimating density)
- SFE State Forest Enterprise (a type of production forest)
- SHCA Species and Habitat Conservation Area (one type of protected area in Vietnam)
- SMART Spatial Monitoring and Reporting Tool
- SVW Save Vietnam's Wildlife
- WS Wildlife Sanctuary
- WWF World Wide Fund for Nature

Executive summary

1. Introduction

1.1. Vietnam is among the world's top priorities for gibbon conservation, harbouring six of the world's 20 species and the highest number of crested gibbon species (genus *Nomascus*) of any country.

1.2. The conservation status of Vietnam's gibbons was first reviewed in 2000, and then updated in 2011. Since the last review 12 years ago, much has changed in Vietnam. Our knowledge of each of the species has improved vastly, due to new and more accurate methods of surveying populations, and due to better coverage of the various sites that gibbons occur in. At the same time, Vietnam has seen rapid economic growth. This has reduced the dependence of local communities on extracting resources from the forest, for example through hunting and the collection of non-timber forest products (NTFPs). But this economic growth has also intensified pressures on gibbon habitats, in particular from agriculture and infrastructure development.

2. Cao vit gibbon (Nomascus nasutus)

2.1. The cao vit gibbon stands out as the most geographically and demographically restricted gibbon species in Vietnam. Its global population consists of fewer than 80 individuals, divided into 11 groups. All of these individuals are found within a solitary forest patch of < 5,000 ha that spans the Vietnam-China border. Nine of these groups occur in Vietnam (Trung Khanh District, Cao Bang Province), over an area of just 890 ha. The new population estimate, which was derived from an analysis of the unique songs made by individual gibbon males, is 38% smaller than previously thought, likely due to accidental double-counting in previous surveys.

2.2. The global population of the cao vit gibbon appears to be at least stable, and may possibly be increasing (as indicated by observations of new groups forming in China). However, the major threat to the long-term persistence of the species is its inherently small population size. This leaves the species vulnerable to inbreeding, genetic diversity loss and chance events that can wipe out small populations. These chance events include unexpected changes in the environment, fluctuations in birth or death rates, and unexpected disasters like disease outbreaks.

2.3. At present, the cao vit gibbon inhabits a mere 25% of the 4,839 ha forest patch it is restricted to. An urgent priority, therefore, is to improve the habitat quality of the forest for the species (e.g. through assisted natural regeneration and enrichment planting) and thereby allow the population to increase in size.

3. Western black gibbon (Nomascus concolor)

3.1. The western black gibbon is represented by a single viable population in Vietnam, spanning the areas of Mu Cang Chai SHCA and Muong La NR (Yen Bai and Son La provinces, respectively). This population is split into two sub-populations, estimated to contain just seven and 13 groups, respectively. These sub-populations are, in principle, connected by a 16 km long corridor of forests in Mu Cang Chai SHCA, but the forests are heavily degraded and bisected by a paved road.

3.2. The small size of each of the western black gibbon sub-populations, even without additional pressures, places them at risk of eventual extinction due inbreeding, reduction in genetic diversity, and chance events. This is layered upon the more immediate threats posed by unsustainable cardamom cultivation and illegal logging, both of which are seriously degrading the habitat quality for gibbons. The strategies currently in place to address these threats, which are taking place within the two designated protected areas, are insufficient in effectively curbing these challenges.

3.3. It is difficult to assess the gibbon population trend in Mu Cang Chai – Muong La, due to the survey methods used to date (and the potential biases that double-counting might have introduced, as happened previously in cao vit gibbon surveys). Given the ongoing threats, however, it appears likely that the population is declining overall in the landscape (even though the northern sub-population appears to be stable or might possibly be increasing).

3.4. Unless circumstances change for the western black gibbon in Vietnam, it could become the first gibbon species to be extirpated from the country. Already, a key population in Hoang Lien-Van Ban NR has been lost. A robust and well-resourced conservation response is urgently needed in Mu Cang Chai SHCA and Muong La NR to turn around the fortunes for the species.

4. Northern white-cheeked gibbon (Nomascus leucogenys)

4.1. The northern white-cheeked gibbon occurs across five provinces in northern and northcentral Vietnam. Many populations have been extirpated in recent decades, with remaining populations being mostly small and isolated. Yet, in the southern part of its range, several population strongholds still exist, including in Pu Mat NP, Vu Quang NP and the contiguous forests of Xuan Lien NR and Pu Hoat PF. Together, these forests are estimated to hold in excess of 700 groups. Other unsurveyed forests along the border with Laos, spanning Nghe An and Ha Tinh provinces, may harbour additional groups that have yet to be identified.

4.2. Information on trends in northern white-cheeked gibbon populations is lacking in certainty. However, it appears likely that all populations are below 'natural' densities, due to historical hunting pressure, habitat loss and degradation, and the effects of population isolation. Anecdotally, it appears that hunting pressures on the species are now declining overall, but some important populations (such as in Pu Hoat PF) remain under threat. Rates of habitat loss and degradation, too, are likely declining, simply because most of the remaining forest is protected from clearance and-or has been logged already.

4.3. With apparent declines in Laos and extinction in China, Vietnam has an increasingly important international role in the conservation of the northern white-cheeked gibbon. Relatively little conservation attention has been given to the species to date, except in Pu Mat NP, where NGOs and the park are working closely together to improve protections for gibbons and other wildlife. An urgent priority is to extend these protections across other key populations of the species, allowing them to recover over the long-term.

5. Southern white-cheeked gibbon (Nomascus siki)

5.1. The southern white-cheeked gibbon has a relatively restricted range, occurring primarily in Quang Binh Province in central Vietnam (but also extending into Ha Tinh and Quang Tri provinces). Within this restricted range, though, significant areas of contiguous habitat remain for the species. Indeed, recent surveys have uncovered > 500 groups in a 100 km long corridor of forests along the border with Laos. Protected strongholds for the species include Phong Nha-Ke Bang NP and Dong Chau-Khe Nuoc Trong NR (harbouring an estimated 200+ groups together), but a substantial proportion of groups (44%) remain outside the protected area network (e.g. in Quang Ninh PF and Khe Giua SFE).

5.2. Population trends for the southern white-cheeked gibbon remain unknown, with baseline surveys in most sites having only recently been completed. Encouragingly, no site extinctions have been documented for the species. Population densities have been estimated to be relatively high in some sites (e.g. the adjacent Dong Chau-Khe Nuoc Trong and Bac-Huong Hoa NRs), although production forests show depressed densities, likely owing to the poorer protections and habitat quality offered by these sites.

5.3. Almost no conservation resources have been directed at the southern white-cheeked gibbon, beyond population surveys. Given the enhanced understanding of the species' situation in Vietnam, and with priority areas having now largely been identified, conservation efforts for the species must be stepped-up. A major priority is to work with management authorities in production and protection forests to improve the conservation of their nationally-and globally-significant gibbon populations.

6. Northern yellow-cheeked gibbon (Nomascus annamensis)

6.1. The northern yellow-cheeked gibbon was only formally recognised as a distinct species in 2010, but since then population surveys across eight provinces in south-central Vietnam have revealed six key sites for the species, including: the contiguous Dak Rong and Phong Dien NRs; the contiguous Saola NRs and Bach Ma NP; Song Thanh NP; Kon Plong District; a trans-provincial complex of forests including Kon Ka Kinh NP, and Chu Mom Ray NP. Populations elsewhere appear to be small and isolated.

6.2. Population densities of the northern yellow-cheeked gibbon appear to have declined everywhere below 'natural' levels, owing to hunting, habitat loss and habitat degradation. Population trend data are sparse, but results from repeated surveys in three sites (Kon Cha Rang NR, the Saola – Bach Ma landscape and Dak Rong NR) indicate population declines. Gun hunting likely continues to be a threat to this species in the south of its range (Kon Tum, Gia Lai and Quang Ngai provinces). This area is also poised to experience further large-scale development of infrastructure and agriculture, intensifying pressures on the species.

6.3. Substantial landscape-scale investments in conservation have been made within the northern yellow-cheeked gibbon's geographic range (primarily in Thua Thien Hue and Quang Nam provinces), which have likely benefitted the species. The species has also been the subject of primate-focussed conservation projects in Kon Tum and Gia Lai provinces. Despite these efforts, the species remains under the gravest threat compared to the other three light-cheeked gibbon species. The urgent conservation priorities are to address gun hunting in the south of the species' range and to improve the management of unprotected populations in the Central Highlands (such as in Kon Plong District).

7. Southern yellow-cheeked gibbon (Nomascus gabriellae)

7.1. The southern yellow-cheeked gibbon has the largest geographic range of Vietnam's gibbon species, occurring over 10 provinces in the south of the country. However, within that broad extent, populations are highly fragmented. Remaining strongholds for the species include: Cat Tien NP and adjoining Dong Nai Culture and Nature Reserve; a complex of forests on the Langbiang plateau (including Chu Yang Sin NP, Bi Dup-Nui Ba NP and Phuoc Binh NP), and Bu Gia Map NP (connecting to populations in Cambodia).

7.2. Threats to the southern yellow-cheeked gibbon from habitat loss and degradation appear to have declined over the previous decade in Vietnam, although trends in hunting and trade of the species remain uncertain. Population trends for the species remain ambiguous in most sites, although the Nam Cat Tien population (within Cat Tien NP) appears to be increasing.

7.3. Conservation efforts in Vietnam for the southern yellow-cheeked gibbon have primarily been undertaken as part of broader biodiversity conservation efforts in flagship protected areas (including in Cat Tien and Bi Dup-Nui Ba NPs). Additionally, a dedicated rescue and rehabilitation centre exists for the species in Dao Tien Endangered Primate Species Centre, with 12 individuals having been successfully released to date. This centre is leading the way on gibbon reintroduction efforts within Vietnam, and the knowledge gained from its activities holds relevance for all gibbon species across the country.

8. Knowledge gaps

8.1. Major gaps remain in our understanding of the status of, and threats to, all of Vietnam's gibbon species. For the cao vit gibbon, this includes our understanding of its population genetic health and habitat restoration requirements. For the western black gibbon, the species' fundamental ecology and behaviour remains poorly understood in Vietnam, hindering decision-making; population surveys for this species must also be undertaken using more accurate methods. For the northern white-cheeked gibbon, population surveys are needed in unprotected forests along the Laos border and updated information is needed on the viability of various small remnant populations. For the southern white-cheeked gibbon, gaps in the population survey data remain, especially in the northern part of its range. For the northern yellow-cheeked gibbon, gaps also remain in the population survey data, especially outside protected areas. The life-history of the northern yellow-cheeked gibbon is also poorly known, limiting effective monitoring and management of populations. The scale and intensity of the hunting threat to the two southern species – the northern and southern yellow-cheeked gibbons – remains poorly understood from a social and ecological perspective, hindering efforts to robustly combat this threat.

8.2. For the four light-cheeked gibbon species, the range boundaries between species also remain to be refined in higher resolution. Despite considerable improvements in our understanding that occurred prior to the last status review, uncertainties in the geographic range limits persist (including extent of overlap and hybridisation). In turn, this is causing some uncertainty in the prioritisation of key sites for the conservation of each species.

9. Conclusions

9.1. Two major themes have emerged during this status review. The first of these is the discovery of surprisingly large gibbon populations in parts of Vietnam's remnant forests, rivalling those reported from Laos and Cambodia. Vietnam is now a more prominent international priority for conservation actions to safeguard gibbons than it has been in the past. Second, there is an emerging sense that gibbon populations in some sites have already reached their lowest ebb and are starting to rebound, or will have the potential to if well-managed. With conservation action, the bottleneck which gibbon populations have been forced through in recent decades may begin to widen once again. This sets the scene, perhaps in the next status review, for discussions to begin about the long-term recovery of gibbon populations in parts of Vietnam and a broader restoration of the ecological and cultural role that gibbons play in Vietnam's forested landscapes.

Introduction

1. Introduction

1.1. Why do Vietnam's gibbons need an updated status review?

Vietnam is amongst the highest priority countries for the conservation of gibbons (Hylobatidae) globally, with as many as six species occurring within its borders, 30% of all gibbon species (**Table 1**). The future for the *Nomascus* genus of gibbons, in particular, is strongly dependent on Vietnam, with six of the seven species occurring in the country (only the Hainan gibbon *Nomascus hainanus* does not occur in Vietnam).

The conservation status of Vietnam's gibbon species was last reviewed comprehensively by Rawson *et al.* (2011). In turn, this review built upon the foundation of a review 10 years earlier by Geissmann *et al.* (2000). These status reviews provided the fundamental knowledge of the status and threats to gibbons that has underpinned more than two decades of work to save gibbons in Vietnam from extinction.

Over the 12 years that has elapsed since the last review, however, our knowledge about the status of Vietnam's six gibbon species has advanced considerably. New surveys using more robust approaches – including the use of 'vocal fingerprinting' for the cao vit gibbon (*N. nasutus*) and spatially explicit capture-recapture for the northern yellow-cheeked gibbon (*N. annamensis*) – have provided us with more accurate information upon which to assess priorities and devise management strategies. The status of the southern white-cheeked gibbon (*N. siki*) is also much better known than it was in 2011, with extensive surveys now completed across much of its geographic range, including large areas of forest outside the protected area network. The ecological importance of gibbons in Vietnam has also now been demonstrated, with in-depth studies of the role that southern yellow-cheeked gibbons (*N. gabriellae*) play in seed dispersal having been completed for the first time.

The threats facing gibbons in the wild have also evolved since the last status review. As Vietnam has developed economically, more people have migrated to towns and cities for work, and millions more families have become less dependent on forests for their livelihoods than before. Although the true extent of gibbon hunting is often difficult to quantify, anecdotal reports from several sites suggest that hunting is on the decline. Known cases of hunting of the very rare cao vit gibbon and western black gibbon (*N. concolor*) are now more than 20 and 10 years old, respectively.

With new information from population surveys, and an updated view of the threats facing gibbons, it is evidently time to take stock of Vietnam's gibbon populations once again.

1.2. Aim and approach

The aim of this report is to reassess the quantitative status, trends and overall threats to each gibbon species in Vietnam, integrating all the new information that has emerged since the last review in 2011. For our information, we drew primarily upon published information in English- and Vietnamese-language scientific journals (which has increased substantially in recent years), supplemented with unpublished reports that we were aware of and had access to, as well as personal communication with primatologists and conservationists with pertinent information. Unlike the last status review, we did not mobilise new surveys as part of the approach, but have highlighted key knowledge gaps for each species, as well as a list of sites that would be a priority to survey before the next status review (see *Appendix I*). We explicitly

do not offer detailed recommendations on conservation actions for each species, since these are best devised and agreed in a participatory workshop environment, where all stakeholders have an opportunity to input to the process. However, we do identify some broad priorities that emerged from the process of reviewing the status of each species.

The structure of each species account is standardised as follows. First, we review the distribution of the species, and briefly provide context on its status in any other country it occurs in. We then review the status of populations in Vietnam, focussing on the key sites for the conservation of the species. The population trend, if known at any sites (e.g. from repeated population surveys) is reviewed next, followed by available population density estimates. Population density is a useful metric for the health of gibbon populations, in particular to help assess if they are at or close to carrying capacity, or if they are heavily depressed (e.g. due to hunting pressure and-or habitat degradation). If population density estimates are available from other countries, these are highlighted in this section and compared to those in Vietnam. Next, we summarise any new fundamental research that has been done on the species in Vietnam (or from other countries, where relevant). We then identify some key knowledge gaps for the species, in particular with respect to the conservation status of the given species in the wild (other knowledge gaps may be important to fill when designing effective conservation interventions, or if conducting fundamental ecological or behavioural research). Threats are discussed next, with particular attention drawn to any threats that have emerged since the last review, and-or any recent changes in the nature of the threats. Finally, we provide a brief overview of publicised conservation efforts for each species in Vietnam, as well as ex-situ holdings of the species (including if breeding and-or wild releases are being done) and relevant national policy.

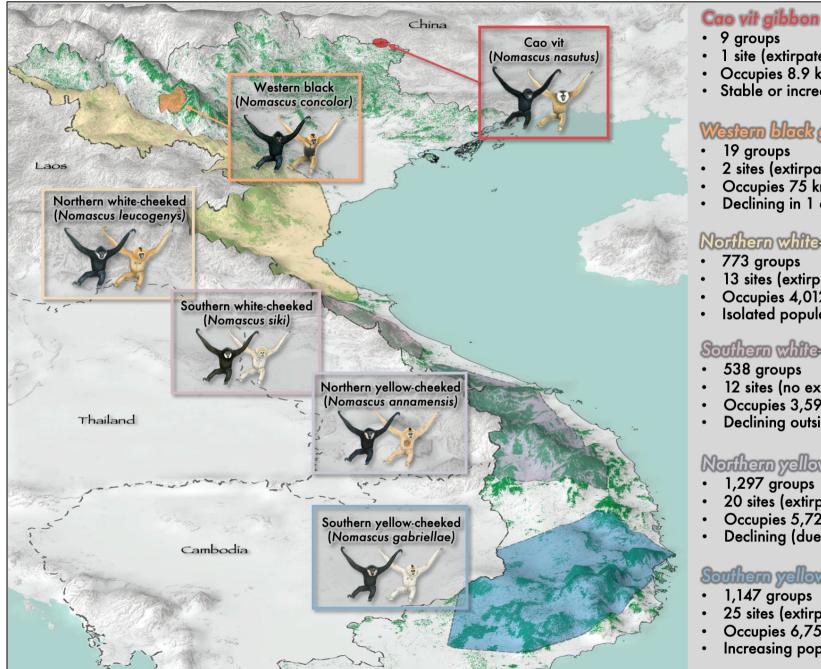
Each species account is supplemented by a detailed, site-level table providing all available population information. Sites are here defined using the more pragmatic approach of management units, rather than gibbon population units.

Country	Gibbon species
Indonesia	9 – Hylobates abbotti, Hy. agilis, Hy. albibarbis, Hy. funereus,
	Hy. klossii, Hy. Iar, Hy. moloch, Hy. muelleri, Symphalangus syndactylus
Vietnam	6 – Nomascus annamensis, N. concolor, N. gabriellae,
	N. leucogenys, N. nasutus, N. siki
Laos	6 – Hy. lar, Hy. pileatus, N. annamensis, N. concolor, N. leucogenys,
	N. siki
Malaysia	5 – Hy. abbotti, Hy. agilis, Hy. funereus, Hy. lar, S. syndactylus
China [†]	4 – Hoolock tianxing, N. concolor, N. hainanus, N. nasutus
Myanmar	4 – Ho. hoolock, Ho. leuconedys, Ho. tianxing, Hy. lar
Thailand	4 – Hy. agilis, Hy. Iar, Hy. pileatus, S. syndactylus
Cambodia	3 – Hy. pileatus, N. annamensis, N. gabriellae
India	1 – Hoolock hoolock
Bangladesh	1 – Hoolock hoolock
Brunei	1 – Hylobates funereus
+ .	

 Table 1. Gibbon species occurring in each country and number of species in total.

[†]*N. leucogenys* and *Hy. lar* are considered extinct in the wild in China, although there is a national aspiration to reintroduce both species (Fan P. F., pers. comm., 2023); *Ho. hoolock* may also occur in China (bordering Arunachal Pradesh, India), although unconfirmed.

Box 1. Meet Vietnam's six species of singing, swinging apes



- 1 site (extirpated from ≥5)
- Occupies 8.9 km²
- Stable or increasing population

Western black gibbon

- 2 sites (extirpated from ≥6)
- Occupies 75 km²
- Declining in 1 of 2 sites

Northern white cheeked gibbon

- 13 sites (extirpated from ≥ 10)
- Occupies 4,012 km²
- Isolated populations are declining

Southern white cheeked gibbon

- 12 sites (no extirpations yet)
- Occupies 3,599 km²
- Declining outside protected areas

Northern yellow-cheeked gibbon

- 1,297 groups
- 20 sites (extirpated from ≥3)
- Occupies 5,728 km²
- Declining (due to hunting)

Southern yellow-cheeked gibbon

- 1,147 groups
- 25 sites (extirpated from ≥5)
- Occupies 6,759 km²
- Increasing population in some sites

Cao vit gibbon

(Nomascus nasutus)

Image: © Nguyen Duc The / Fauna & Flora

Fast facts:

- Found in just one forest patch of < 5000 ha situated on the Vietnam-China border (Cao Bang Province, Vietnam and Guangxi Province, China)
- 11 family groups known globally (nine wholly or partially in Vietnam), totalling 74 individuals
- Population is likely stable or slowly increasing
- Very small population is however vulnerable to chance events, catastrophes, genetic diversity loss and inbreeding
- Restoration of its limestone forest habitat on the Vietnam-China border is an urgent priority

2. Cao vit gibbon (Nomascus nasutus)

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Summary

- The cao vit gibbon (*Nomascus nasutus*) is found in one small (<5,000 ha) forest block on the Vietnam-China border; no major changes in its distribution have occurred since the last status review
- Gibbon occupancy of available habitat remains low (25%), likely because of poor habitat quality and human disturbance; two newly-formed groups in recent years have however been observed in previously unoccupied habitat in China
- A recent population survey using more accurate and objective methods has revealed that the population size has likely been over-estimated in the past; there appears to be <80 individuals in less than a dozen family groups remaining (of which nine groups wholly or partially occur in Vietnam)
- The very small size of the population puts it at risk of extinction from: chance events (e.g. variations in breeding rates or in the environment), unforeseen catastrophes (e.g. disease), long-term genetic diversity loss, and inbreeding depression
- Habitat restoration through reforestation, enrichment planting and assisted natural regeneration is of the utmost importance and urgency for the species, in order to increase its population size as soon as possible
- Major knowledge gaps for the species include our currently poor understanding of its population genetic health, as well as the lack of effective protocols for the restoration of gibbon habitat in limestone areas

2.1. Distribution

The cao vit gibbon (sometimes called the eastern black crested gibbon) holds the distinction of being the rarest and most range-restricted of Vietnam's gibbon species, now found only in one forest block of 4,839 ha straddling the Vietnam-China border (**Fig. 1**). In Vietnam, it occurs only in the district of Trung Khanh, Cao Bang Province (Wearn *et al.* 2021b).

Knowledge of the distribution of the cao vit gibbon has been marginally refined since 2011. At the time of Rawson et al. (2011), there was still some minor uncertainty about whether the population in Trung Khanh really was the last population of the species in Vietnam. As of 2023, that uncertainty has narrowed still, with no reports of the species in the last decade from anywhere else in Vietnam (**Table 2**). If the species does persist outside Trung Khanh, the most likely place to find it might be Kim Hy NR, where the forest is apparently of relatively good quality (Trinh-Dinh, H., pers. obs., 2023). We consider its persistence in Kim Hy highly unlikely, though, given that no records have materialised from the site in over 20 years.

Recent surveys, as well as long-term monitoring, have provided us with an estimate of the area of occupancy of the species: 1,215 ha across Vietnam and China, of which 890 ha (73%) is in Vietnam (**Fig. 2**).

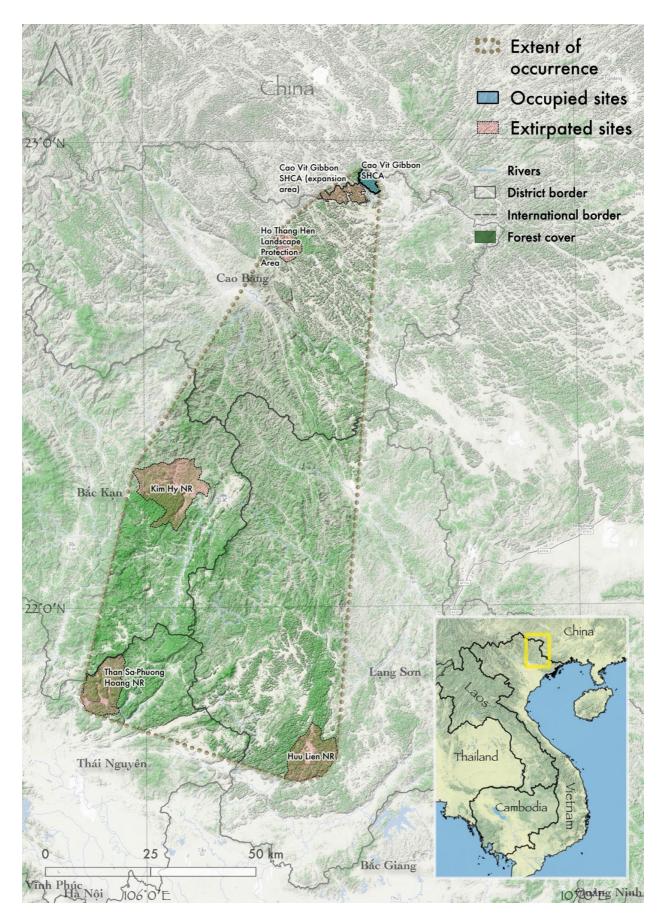


Figure 1. Extent of occurrence of the cao vit gibbon (*Nomascus nasutus*) in Vietnam since 2000. Only a single population remains, situated on the Vietnam-China border. Forest cover for 2022 was extracted from the Global Forest Change dataset (Hansen *et al.* 2013).

Table 2. Cao vit gibbon (*Nomascus nasutus*) sites in Vietnam since 2000.

		A	C	Deserved of the		Group	C	Ohan na ain sa laat	
Site	Province	Area (ha)	Survey year	Recorded # groups	Estimated # groups	density, per km ²	Survey methods	Change since last assessment	Source
Cao Vit Gibbon Species & Habitat Conservation Area	Cao Bang	1,678	2021	9	9	0.54	Acoustic recording and vocal fingerprinting ^a	17 groups estimated in 2007, but this appears to have been a gross overestimate; the population nonetheless appears to be stable or possibly increasing	Wearn <i>et al.</i> 2023a
Cao Vit Gibbon Species & Habitat Conservation Area – <i>extension</i> <i>area</i>	Cao Bang	3,219	2009	Extirpated	-	-	Listed as 'Lung Ri forest' in Rawson et al. (2011)	Treated as 'provisionally extirpated' in the last review; now assumed to be extirpated, with no recent records	Rawson <i>et al.</i> 2011
Ho Thang Hen Landscape Protection Area	Cao Bang	3,220	1999	Extirpated	-	-	Interviews		Geissmann <i>et</i> al. 2000
Kim Hy Nature Reserve	Bac Kan	15,416	2009	Extirpated	-	-	Listening post survey	Treated as 'provisionally extirpated' in the last review; now assumed to be extirpated	Rawson <i>et al.</i> 2011
Than Sa-Phuong Hoang Nature Reserve	Thai Nguyen	17,477	2011	Extirpated	-	-	Listening post survey	Treated as 'provisionally extirpated' in the last review; now assumed to be extirpated	Rawson <i>et al.</i> 2011
Huu Lien Nature Reserve	Lang Son	10,915	2000	Extirpated	-	-	Interviews	Not listed in Rawson et al. (2011); added as a site where gibbons were reported in the 21 st Century from local interviews	Geissmann <i>et al.</i> 2000
		Total groups (all time periods)		9	9				
		Total groups - recent only (post 2011)		9	9				

^aMale gibbons were identified from acoustic recordings based on the unique characteristics of their song, leading to a far lower estimate of the number of groups than previously thought.

2.2. Population status

Despite the small area occupied by the cao vit gibbon, surveying the species and estimating its population size has proven challenging. One approach has been to identify individual groups from detailed observations of their composition, pelage differences, and the pattern of their song, as has been done in China during the course of long-term studies of focal groups (Fan *et al.* 2010, 2015; Ma *et al.* 2020a). However, this is a highly resource-intensive approach, due to the shy and cryptic nature of the cao vit gibbon – as indeed is the case for all of Vietnam's gibbon species – and the difficult-to-access karst landscape it inhabits. Currently, four groups each in China and Vietnam are subject to this kind of intensive, focal group monitoring and it would be difficult to scale this up to the whole population without a step-change in available resources.

Given available resources, a different approach must be taken to estimate the size of the cao vit gibbon population. Previous surveys have taken a 'snapshot survey' approach instead of the focal group monitoring approach. In a snapshot survey, all groups (as well as the individuals within those groups) are counted within a short space of time, using multiple teams of surveyors spread out simultaneously over a large area to ensure no gibbons are missed (Ma *et al.* 2020b). This makes sense, since it is less resource-intensive and can be completed within a time-frame that is short enough to assume the population is not changing as it is measured. Surveys with this method were done in 2007, 2012, 2016 and 2018, estimating approximately 19-20 groups and 120 individuals (summarised in Wearn *et al.* 2021b), but with a wide variation (e.g. 109 individuals in 2018 and as many as 137 individuals in 2012). Approximately 17-18 groups were thought to occur within the Vietnamese portion of the species' range (Rawson *et al.* 2011; Ma *et al.* 2020b).

However, it has become apparent that the methods used in surveys prior to 2021 likely led to over-estimation of the population through inadvertent 'double-counting', i.e. counting the same group more than once (Wearn *et al.* 2023a). This likely occurred when gibbon groups called multiple times in a day from locations far apart, and-or when gibbon groups called from widely disparate parts of their home-range on different survey days. In both cases, surveyors sometimes 'split' a single group into two or more groups, creating 'phantom groups' in the data that didn't actually exist.

To circumvent the subjectivity inherent in part surveys, the most recent survey in 2021 used 'vocal fingerprinting' to identify and count the groups (Wearn *et al.* 2023a). Cao vit gibbons, in particular the adult males, have unique signatures in their songs which betray the identity of a singing gibbon (Feng *et al.* 2014; Wearn *et al.* 2023a). Vocal fingerprinting was combined also with drone-mounted thermal video to assist with counting the number of individuals within groups (Wearn *et al.* 2023b). This survey estimated that the population was 38% smaller than previously thought, at 11 groups and 74 individuals. Of these, 9 groups occurred on the Vietnamese side of the border.

2.3. Population trend

The trend in the cao vit gibbon population is difficult to ascertain, given the challenges in monitoring the species accurately and the subjectivity inherent to the methods. Surveys between 2007 and 2018 using similar methods do not, however, show any obvious trend, suggesting that the population is at least stable (Wearn *et al.* 2021b).



Figure 2. Area occupied globally by the cao vit gibbon (*Nomascus nasutus*) in the Trung Khanh – Bangliang forest block (coloured in white), derived from long-term monitoring data (C. Ma & P. Fan, 2022 and O. R. Wearn / Fauna & Flora, 2023), as well as population survey data from 2021 (Wearn *et al.* 2023a). The forest on the Vietnamese and Chinese side of the border is protected in the Cao Vit Gibbon Species and Habitat Conservation Area and Bangliang National Nature Reserve, respectively. Basemap is a composite PlanetScope satellite image for May-August 2020.

Evidence from long-term monitoring in China is more hopeful: two groups have been observed forming in areas not previously known to be occupied by the species (one in 2015 and one in 2017). In addition, remotely-sensed evidence, as well as fixed-point photography and anecdotal observations, all suggest that the forest is recovering from past disturbances (Fan *et al.* 2013; Wearn *et al.* 2021b), which should provide the population with improved food resources and allow it to expand.

2.4. Estimated population density

Based on the 2021 survey and long-term data (Wearn *et al.* 2023a), the population occupies an area of 1,215 ha, giving a density of 0.91 groups or 6.1 individuals per km². Considering the area of the whole Trung Khanh – Bangliang forest block (4,839 ha), the density is 0.23 groups or 1.5 individuals per km².

Exclusively in Vietnam, the densities are 1.01 groups or 6.9 individuals per km^2 inside the occupied area, and 0.32 groups or 2.20 individuals per km^2 for the area of the forest block. For the Cao Vit Gibbon SHCA, the density is 0.54 groups per km^2 (**Table 2**).

2.5. Recent research findings

The cao vit gibbon is a better-studied species than it was in 2011. A long-term monitoring project for the species began in 2007 in China and, at the time of the last status review, had only been ongoing for a few years (Fan et al. 2010, 2011; Fan, Fei & Ma 2012). Now, this project has generated more than 15 years of data, revealing the detailed ecology and social behaviour of five study groups (Fan et al. 2015; Ma, Liao & Fan 2017; Ma et al. 2019, 2020a; Ma, Ma & Fan 2022). From a conservation perspective, this study has proved invaluable due to the demographic and socioecological data it has generated; in turn, these data have been essential for parameterising population viability analyses (PVAs) of the species (Fan et al. 2013; Wearn et al. 2021b). For example, we know that infant and juvenile survival was relatively high in the studied groups from 2008-2020 (with 84% and 89% recruitment for the infant and juvenile age-classes, respectively; C. Ma & P. Fan, 2021, unpublished data) and that females bred as frequently, or even more frequently, compared with other gibbon species (Fan et al. 2015). This is a cause for optimism about the long-term viability of the species and means it is more robust to challenges from natural catastrophes (e.g. disease or extreme weather) or other unforeseen events (e.g. hunting) than might have been expected given the population's small size (Wearn et al. 2021b).

The long-term study in China, combined with recent observations in Vietnam, has also confirmed that polygyny (groups composed of two females and a single male) is the typical group structure of the cao vit gibbon. This does not seem to be a 'crowding effect' of living in a restricted area of habitat and, as is also the case for *N. concolor*, is more likely to be an adaptation to the unique challenges faced by gibbons living in highly seasonal, sub-tropical forests (Fan *et al.* 2015; Guan *et al.* 2018).

Long-term studies are also revealing the cao vit gibbon's requirements for space and habitat. Home-ranges of the cao vit gibbon are larger than is typical for gibbons, perhaps due to the lower availability of fruit in sub-tropical forests (Guan *et al.* 2018). Early data suggested homeranges of around 130 ha (Fan *et al.* 2010), but home-ranges have since been found to vary considerably, between groups and over time (Ma *et al.* 2020a). In Vietnam, available data for four studied groups (2020-2023) suggest home-ranges of 80-120 ha (O. R. Wearn / Fauna & Flora, unpublished data, 2023). Groups that are larger (8 or 9 individuals) and-or inhabit more degraded habitat with lower resources may require larger home-ranges.

In addition to improved ecological knowledge of the cao vit gibbon, recent work has also begun to advance our understanding of the broader human cultural and social system that the gibbon persists in. Local communities in Trung Khanh District are overwhelmingly composed of those from the Tay ethnic minority, with a small proportion from the Nung ethnic minority. These communities express very high awareness of the gibbon (93% of respondents) and support for its conservation, with 83% of respondents stating that they had a responsibility to protect the gibbon and 73% reporting that they felt the conservation project benefitted local communities (Nguyen H. A. / Fauna & Flora, unpublished data, 2021). Hunting of the gibbon has now stopped, but the lack of available land in the valleys surrounding the protected area inevitably means that there are conflicts with local livelihoods, including grazing and collection of NTFPs and firewood inside the protected area. Fauna & Flora has been working with these communities for more than 20 years and there is evidence that the awareness-raising and livelihoods activities have led to greater knowledge of the gibbon and its conservation, as well as more 'pro-conservation' attitudes and behaviours (Nguyen H. A. / Fauna & Flora, unpublished data, 2021). With this broader ethno-

primatological focus, more effective conservation activities are being designed, that are supported by and help local communities, as well as reduce pressures on the gibbon and its habitat.

2.6. Knowledge gaps

Despite recent ecological and behavioural studies of the cao vit gibbon, there remain at least three major gaps in our knowledge of the species. First, the population's genetic health – including its genetic diversity and the extent of inbreeding – remains entirely unknown. This was identified as a key source of uncertainty when the population's viability was last assessed in 2021 (Wearn *et al.* 2021b). Knowledge of the genetic health of the population would help to more effectively prioritise amongst the range of potential conservation actions available for the species. It also defines the time-line over which interventions to increase the population size must occur to steer the population safely away from entering an extinction vortex (Gilpin & Soule 1986).

Second, food competition between the cao vit gibbon and sympatric frugivorous species, especially the three species of macaques (*Macaca mulatta*, *M. assamensis*, and *M. arctoides*), has never been investigated. Based on anecdotal observations, macaque populations have increased rapidly in the past two decades due to the conservation management of the two protected areas. Illegal hunting of macaques (as well as gibbons) has been well controlled. In China, no gunshots or snares have been heard or found in the past 15 years. In Vietnam, too, incidents of gun hunting are very rare and snaring is declining. With the increase in the macaque populations, food competition with gibbons may also be increasing. This topic requires more in-depth investigation, including the extent of dietary overlap between macaques and gibbons, behavioural interactions at fruiting trees, and the overall impacts on gibbon foraging and caloric intake over space and time.

Third, knowledge of the species' habitat requirements and restoration needs remains in its infancy. The habitat of the cao vit gibbon was severely degraded in the past, due to the effects of timber extraction, charcoal production, grazing and firewood collection. The species occurs in the lowest forest of any gibbon species, with an average canopy height of just 11 m in the core area occupied by gibbons (Fan *et al.* 2011; Vu Quang & Phung Van 2021). This poor state of the habitat appears to be a factor in constraining the growth of the population, with just 25% of the 'Trung Khanh – Bangliang' forest block actually used by gibbons (**Fig. 2**). Natural regeneration appears to be happening over large areas (Wearn *et al.* 2021b), but this may not occur quickly enough, nor produce the best habitat for the gibbon (e.g. favouring pioneer species that may not be a favoured food source).

Assisted natural regeneration (principally, to reduce competition from grasses), enrichment planting, and reforestation have all been implemented in the site. These restoration efforts been underpinned by much-needed study of the diet of the cao vit gibbon (Fan *et al.* 2011). Species chosen for planting are those that have been found to be favoured by the cao vit gibbon (Tran Duc & Dine 2012). However, restoration efforts have not yet been able to reach the scale necessary (i.e. 100's of hectares) to see positive impacts on the gibbon's population size. Restoration of karst forest remains challenging, due to poor accessibility of sites and a lack of clear and effective protocols on species selection, planting and care in limestone areas (Insua-Cao *et al.* 2012). An investment in long-term research to develop effective methods for restoring the cao vit gibbon's karst habitat is urgently needed.

2.7. Emerging threats

Given that the population is smaller than was previously thought, small population size effects – including genetic diversity loss, inbreeding and vulnerability to stochastic and catastrophic events – are now known to be an even greater threat to the species. This makes actions to increase the population size the highest priority. Likely the most feasible action is to rapidly restore the quality and extent of the habitat in the Trung Khanh – Bangliang forest block, allowing the population to expand and grow at a faster rate than is likely occurring currently.

Habitat degradation, which was previously identified as a threat to the species (Rawson *et al.* 2011), is no longer considered to be of high concern among stakeholders (Wearn *et al.* 2021b), with charcoal production having ended in the landscape and other habitat disturbances continuing to decline. This likely reflects improvements in law enforcement within the gibbon's two protected areas, as well as broader trends regionally, in which local communities are becoming less dependent on forests as their economic security and wealth becomes more tied to urban areas. The exception to this trend of reduced habitat degradation appears to be in China, where grazing continues to negatively affect potential gibbon habitat in the Bangliang National Nature Reserve.

It remains the case that no incidences of gibbon hunting have been recorded since conservation efforts began in 2002 and hunting no longer has an impact on the population dynamics of the species. However, with the emergence of the Covid-19 pandemic, local communities living in proximity to the gibbon were apparently put under greater economic hardship, due to the loss of family jobs in cities and a closure of trade across the Vietnam-China border (Nguyen Duc T., 2021, pers. comm.). Patrols within the gibbon's habitat noticed an increase in forest use by local people, including collection of non-timber forest products (NTFPs), as well as trapping and gun hunting (Fauna & Flora unpublished SMART data, 2020-21). Although the gibbon population is not known to have been seriously affected, it underlines the potential vulnerability of such a small and isolated population to unforeseen events.

Climate change has not yet emerged as a significant threat to the cao vit gibbon as far as is known, but this is likely to change over the coming decades. No down-scaled climate predictions are available for the cao vit gibbon's geographic range, although coarse predictions for the East Asian region indicate that temperatures will greatly increase, the number of frost days will decline and rainfall will become more extreme, with droughts and torrential rain (Gutiérrez *et al.* 2021). This is likely to affect plant community composition in the cao vit gibbon's remaining habitat, with potential knock-on effects on food availability and-or seasonality. Climate change is also likely to increase the risk of forest fires, which could have devastating impacts on habitat quality for the gibbon and set back the last two decades of forest regeneration.

Climate envelope modelling of the cao vit gibbon's range largely agrees with these broader expected trends for the East Asian region. There is predicted to be a net loss of climatically-suitable habitat in northern Vietnam and southern China over the next decades (Trinh-Dinh *et al.* 2022), which may reduce options for recovering the species in parts of its former range. Surprisingly, the currently-occupied Trung Khanh – Bangliang forest block is predicted to remain climatically stable, offering suitable habitat for decades to come (Trinh-Dinh *et al.* 2022). Climate envelope modelling does, however, involve some strong assumptions about how species respond to climate, and the predictions will need validation on the ground.

2.8. Conservation management

2.8.1. In-situ conservation

Conservation efforts for the cao vit gibbon have continued apace over the last decade, with a bolstering of protection levels in the two protected areas holding the species – the Cao Vit Gibbon Species and Habitat Conservation Area in Vietnam and Bangliang National Nature Reserve in China – as well as outreach, educational and livelihoods work with local communities (Wearn *et al.* 2021b). Habitat restoration, which is now so vital given the small size of the population, continues to expand in both Vietnam and China (Wearn *et al.* 2021b). Once this has been achieved, conservation planning to establish a second population of the species would be a priority (Wearn *et al.* 2021b). Long-term monitoring of focal gibbon groups started in 2020 in Vietnam for the first time, replicating the methods used in China, albeit by employing members of the local community instead of academic researchers. An updated conservation plan for the species was agreed by all key stakeholders in 2021, covering the period until 2030 and with a longer-term vision until 2050 (Wearn *et al.* 2021b).

Fauna & Flora remains the key partner organisation committed to the species in Vietnam, alongside People Resources and Conservation Foundation (PRCF) and the Center for Nature Conservation and Development (CCD). All organisations continue to work closely with the district and provincial Forest Protection Department, as well as local communities surrounding the protected area. Over the period 2000-2020, Fauna & Flora invested (including donor funding) \$1.9 million in the site, i.e. approximately \$100 k per year (Fauna & Flora unpublished data, 2020). An order of magnitude more funding is likely required in order to achieve the longer-term vision of stakeholders and truly set this highly-depleted species on the path to recovery.

2.8.2. Ex-situ conservation

No cao vit gibbon individuals are currently in captivity anywhere in the world. Husbandry practices for the species remain poorly-developed, with only a single individual known to have ever been kept captive for a significant period. This individual ('Patzi') was a female held in Tierpark Berlin, Germany, from 1962 until her death in 1986 (Geissmann 1989).

2.8.3. Policy

The cao vit gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. It was not listed as a separate species in Vietnam's national Red Data Book (VAST 2007) and hence remains unassessed. The revised Red Data Book for Vietnam is currently in progress (Nguyen Dinh D., pers. comm., 2023) and will include the species.

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) carry out assisted natural regeneration and tree-planting to recover the species' habitat; 2) reduce habitat degradation from fuelwood collection and grazing (by establishing fuelwood and forage plantations, as well as restricting livestock access to the forest); 3) develop sustainable livelihoods options for local communities by providing training and study tours; 4) encourage transboundary cooperation across the Vietnam-China border between protected areas, forestry and law enforcement officials, and 5) carry out a long-term study of the population dynamics of the species.

To date, the National Primate Action Plan has not made a measurable difference towards the conservation of the species, due to insufficient funding and a lack of coordination from a steering committee (La Quang & Le Khac 2020). We are not aware of any specific activities or resources in Vietnam that have been assigned to the identified actions (La Quang & Le Khac 2020). NGOs have, however, continued their long-term commitment to the conservation of the species in partnership with the local government and Forestry Protection Department, making progress on all five identified actions (as well as other activities besides). In China, specific actions for the species were included in the Management Plan (2018-2022) of the Bangliang National Nature Reserve, including allocation of government funds.

Western black gibbon

(Nomascus concolor)

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Fast facts:

- Only a single viable population remains, split across Mu Cang Chai SHCA and Muong La NR (Yen Bai and Son La provinces)
- Small size of two remaining sub-populations (six and 13 groups, respectively) likely undermines their long-term viability
- Population trends uncertain, but likely declining overall; threats from habitat degradation have increased, primarily due to rapid and large-scale expansion of cardamom cultivation deep inside the PAs
- To avoid extirpation of the species from Vietnam, protections for the species and its habitat, in particular from unsustainable cardamom cultivation, need to be urgently stepped-up

3. Western black gibbon (Nomascus concolor)

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Summary

- The western black gibbon (*Nomascus concolor*) is the second-most restricted gibbon species in Vietnam, today only found in Yen Bai and Son La provinces
- The only viable population occurs over two contiguous protected areas, namely Mu Cang Chai SHCA and Muong La NR (with a second population in Hoang Lien-Van Ban NR either extirpated already or at least functionally extinct)
- The Mu Cang Chai Muong La population, estimated at 19 groups in total, is today split into two disjunct sub-populations (of six and 13 groups, respectively) separated by a 16 km corridor of degraded forests and a narrow paved road with few remaining canopy connections
- Although uncertainties remain about the true population size and trend in Mu Cang Chai – Muong La, the small sizes of the two sub-populations render them vulnerable to extinction from small population size effects (including inbreeding depression, genetic diversity loss and environmental or demographic variation), even in the absence of further threats (which in reality are also growing)
- Threats facing the Mu Cang Muong La population appear to have evolved since the last status review, with gibbon hunting apparently declining (and-or becoming more covert) and habitat degradation becoming more serious, with cardamom cultivation now reaching the upper-most slopes of both PAs, exactly where the remaining gibbons are persisting
- The western black gibbon has been relatively well studied in China, but data from Vietnam are sparse and even the most basic information is unavailable (e.g. on demographic rates, food and habitat preferences, and home-range size); this lack of data precludes a robust analysis of the viability of the population and hinders effective conservation planning for the species
- If a repetition of events in Hoang Lien-Van Ban NR is to be avoided, a robust conservation response is urgently needed in Mu Cang Chai SHCA and Muong La NR, in particular to halt the increasing pressures from unsustainable cardamom cultivation and timber logging; only then might the western black gibbon have a future in Vietnam and long-term plans for its recovery be considered

3.1. Distribution

The western black gibbon (*Nomascus concolor*), sometimes also referred to as the 'western black crested gibbon', is second only to the cao vit gibbon in terms of its highly restricted distribution in Vietnam. Historically, it would have occurred across a sliver of north-western Vietnam, enclosed between the Black and Red rivers (Song Da and Song Hong, respectively). Reports of the species west of the Black River, based on vocalisations and local reports, remain unconfirmed (Nguyen Manh *et al.* 2010a).

Today, the species is found only definitely in one landscape – the contiguous forests of Mu Cang Chai SHCA and Muong La NR (**Fig. 3**). Here, the species is distributed in two subpopulations, which are thought to be isolated in practice due to the large distance (approximately 16 km) between them (**Fig. 4**). The first sub-population, near the village of Che Tao, is the smaller of the two, but appears to be stable (or possible even increasing). The second, larger, sub-population occurs where Mu Cang Chai SHCA and Muong La NR abut, straddling the provincial Yen Bai – Son La boundary. This second population has been under intense anthropogenic pressure in recent years and appears to be in decline as a result. In 2010, one gibbon group was also reported >5 km to the south of the Mu Cang Chai – Muong La landscape, in a separate forest area called 'Hang Si', in Ngoc Chien Commune (Le Trong & Le Minh 2010). No further reports of this group are available and the species has likely now been extirpated from this forest area (**Table 3**).

In the last status review in 2011, the western black gibbon was also reported from Hoang Lien-Van Ban NR, but it was already on a rapidly declining trajectory at that time, with at least one adult male reported to have been shot and killed in 2009 (Rawson *et al.* 2011). Moreover, the handful of remaining groups were separated into three isolated areas, likely intensifying the extinction vortex still further. Since the last surveys in 2009, no additional data have emerged. Multi-taxon biodiversity surveys in 2019, including 45 km of day transects in Hoang Lien-Van Ban NR, did not record any gibbons (Hoang Van *et al.* 2019). However, transects may not have been situated in the correct areas, and may have started too late in the day (7 am) to be optimal for detecting gibbons. A re-survey of this population is needed, with a view to formally assessing whether further conservation action in this site might be effective or not. Other remnant populations reported in the 2000 gibbon status review (Geissmann *et al.* 2000), including four sites across the provinces of Lao Cai, Son La and Phu Tho (Xuan Son NR) should now be considered extinct, with no new reports emerging over the last two decades (**Table 3**).

The western black gibbon also occurs in China and Laos. Indeed, most of the global distribution of the species is in southern China, across southern and central Yunnan Province (Rawson *et al.* 2011; Fan 2017). The 'core' of the species' distribution globally is two parallel mountain chains in central Yunnan – the Wuliangshan and Ailaoshan mountains – which are thought to be home to at least 250 groups (Rawson *et al.* 2011; Fan *et al.* 2022). The species' distribution contracted substantially in China in the latter half of the 20th Century, but some populations appear to be stabilising now (Fan 2017). In particular, the population of ~100 groups on Mt Wuliang appears to be stable or possibly increasing (Fan *et al.* 2022).

The western black gibbon in Laos is considered to be a separate sub-species (*N. concolor lu*) from populations in Vietnam and China (Van Ngoc *et al.* 2010d; b), worthy of conservation in its own right as a distinct evolutionary unit. Today, this sub-species only occurs in north-western Laos, with a remnant population in Nam Kan NPA. Here, the population appears to have declined considerably between 1999 and 2014 – from a density of 2.2 groups per km² (Geissmann 2007) to 0.04 groups per km² (Youanechuexian, Phiapalath & Suwanwaree 2014). The population appears to have retreated in its distribution mostly to the south of the PA, where hunting taboos in a local H'mong village, as well as an ecotourism project ('Gibbon Experience'), have offered the gibbons protection (Youanechuexian *et al.* 2014).

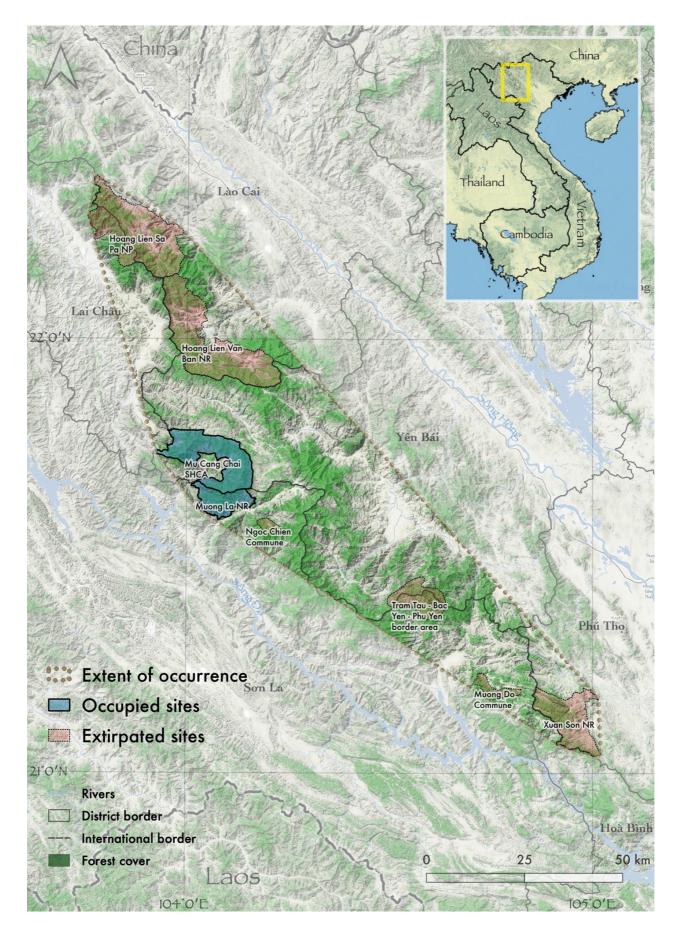


Figure 3. Extent of occurrence of the western black gibbon (*Nomascus concolor*) in Vietnam since 2000. Only a single landscape remains occupied: the contiguous forests of Mu Cang Chai Species and Habitat Conservation Area and Muong La Nature Reserve. Forest cover for 2022 is from the Global Forest Change dataset (Hansen *et al.* 2013).

Only 10 gibbon groups (39 individuals) were confirmed in Nam Kan NPA in the most recent survey (Youanechuexian *et al.* 2014), making the population vulnerable to inbreeding, genetic diversity loss, environmental and demographic stochasticity, and any catastrophic events, such as disease. Other populations in Laos (e.g. in Nam Ha NPA) have dwindled and are either extinct or at least functionally extinct (MAF 2011), echoing the situation in Vietnam.

The fact that Vietnam harbours a small proportion of the total number of western black gibbon groups globally might lead to the conclusion that it has a lower responsibility for conserving the species. But, despite the large western black gibbon population in China, the species remains Critically Endangered and is declining globally (Fan *et al.* 2020). Vietnam still harbours a critical southern nucleus of the species, from which recovery in the broader Hoang Lien mountains might be possible in the future. Gibbons also play an out-sized ecological role in Vietnam's forests as seed dispersers (Bach Thanh *et al.* 2018) and their protection should be considered an integral part of sustainable forest management.

3.2. Population status

The latest population data from the Mu Cang Chai – Muong La population suggested that in 2019 there were 19 groups (64-79 individuals), separated into two sub-populations of six and 13 groups, as well as one apparently solitary male (Tran Van & Nguyen Dinh 2019). The two sub-populations remain connected, in principle, by a 16 km corridor of forests (**Fig. 4**). However, the corridor is now in poor condition, having been degraded in the last two decades through a combination of logging, cardamom cultivation, grazing and conversion to agriculture or pine plantations (Tran Van & Nguyen Dinh 2019). The paving of the Mu Cang Chai – Che Tao road in 2014 further disconnected the two sub-populations. The road is relatively narrow, but there remain only a handful of canopy connections passing over it and it appears unlikely that gibbons would use these paths in practice, given their strong aversion to human disturbance (likely a result of heavy hunting pressure).

The northern 'Che Tao' sub-population of six groups (plus one solitary male) appears to consist of only 18-22 individuals, which leaves it at high risk of small population size effects (including inbreeding, genetic diversity loss and susceptibility to demographic and environmental variation). The Che Tao sub-population used to extend into Lao Chai commune, north of the main ridge running through Mu Cang Chai SHCA, but the most recent survey reported that they had not been confirmed from this area since 2016 (Tran Van & Nguyen Dinh 2019). Up until 2010, a group also used to occur east of the Mu Cang Chai – Che Tao district road, which cuts north-south through Mu Cang Chai SHCA (and was paved in 2014). The most recent information suggests that this group no longer occurs there (Tran Van & Nguyen Dinh 2019). This apparent shrinking in the distribution of the Che Tao sub-population conflicts with our understand of the population size, which available data suggests is stable or possibly increasing, after reaching a low point around 2006 (see Section: *Population trends*).

The southern 'Na Hang – Muong La' sub-population of 13 groups was thought to consist of 46-57 individuals during the 2019 survey, approximately double that of the Che Tao sub-population. This sub-population was previously much larger and has undergone a dramatic decrease over the last two decades, especially during the 2000's (*see next section*). This is mirrored in the distribution of this sub-population, with a clear contraction towards the remote border area between the two protected areas. Areas in the south of Muong La NR, including Nam Pam commune, are now no longer occupied by gibbons.

Table 3. Western black gibbon (*Nomascus concolor*) sites in Vietnam since 2000.

						Group			
		Area	Survey	Recorded	Estimated	density,	Survey		
Site	Province	(ha)	year	# groups	# groups	per km ²	methods	Change since last assessment	Source
Hoang Lien Sa Pa National Park	Lai Chau, Lao Cai	31,371	1998	Extirpated	-	-	Interviews	Not listed in Rawson et al. (2011); added as a site where gibbons may have survived into the early 21st Century	Geissmann <i>et</i> <i>al.</i> 2000
Hoang Lien Van Ban Nature Reserve	Lao Cai	25,669	2009	Extirpated?	-	-	Listening post survey	2 groups were reported from the last survey (in 2009); now considered provisionally extirpated based on the lack of recent records	Rawson <i>et al.</i> 2011
Mu Cang Chai Species & Habitat Conservation Area	Yen Bai	19,454	2019	14ª	14	0.07	Listening post survey	Recorded # groups has remained stable, with 14 groups also reported in 2010	Tran Van & Nguyen Dinh, 2019
Muong La Nature Reserve	Son La	7,959	2019	5	5	0.06	Listening post survey	Recorded # groups decreased from 6 (survey in 2010)	Tran Van & Nguyen Dinh, 2019
Ngoc Chien Commune, Muong La District	Son La	1,500	2010	Extirpated	-	-	Interviews	Not listed in Rawson et al. (2011); added as a site where 2 gibbon groups apparently survived until 2010; presumed now extirpated based on the lack of recent records	Le Trong & Le Minh, 2010
Tram Tau - Bac Yen - Phu Yen district intersection	Yen Bai, Son La	9,000	1999	Extirpated	-	-	Interviews		Rawson <i>et al.</i> 2011
Muong Do Commune, Phu Yen District	Son La	2,500	1999	Extirpated	-	-	Interviews		Rawson <i>et al.</i> 2011
Xuan Son Nature Reserve	Phu Tho	15,589	1999	Extirpated	-	-	Interviews		Rawson <i>et al.</i> 2011
		Total groups (all time periods)		19	19				
		Total gro recent or (post 201	ıly	19	19				

^aNumber of groups excludes one male who was only recorded singing solo; this male may or may not have been part of a family group.

The species appears functionally extinct, if not actually extinct, in Hoang Lien-Van Ban NR. The last population surveys for the species in this PA in 2009 were able to confirm the presence of only two groups, with a further three groups reported by local people (Rawson *et al.* 2011). This represents a precipitous decline since the 2001 estimate of 14 groups (Rawson *et al.* 2011). If any groups survive today, they are highly unlikely to constitute a viable population and would require active management going forward (including, potentially, translocation or captive breeding to allow individuals to contribute to the gene pool of the species).

3.3. Population trends

It is difficult to clearly ascertain the population trend of the species, given the survey methods used to date. Western black gibbon surveys (similar to most gibbon surveys in Vietnam to date) have relied on subjective assignments of group identities, which previous surveyors have noted is difficult (e.g. Le Trong & Le Minh 2010). Methods used have also not accounted for potential missed groups, i.e. those that did not sing during the survey or were not in the area covered by the listening posts. This may be particularly important for this population, given the apparently low calling rate of groups (perhaps a consequence of the low density of the population and-or an adaptation to heavy hunting pressure). Surveys conducted between 2006 and 2019 were at least relatively standardised in their protocols, survey areas and efforts. Earlier surveys done between 2000 and 2001 used less standardised methods, but the numbers of groups recorded have been aggregated from these data as well (Le Trong & Le Minh 2010).

Available data suggest that the Che Tao sub-population was smaller in the past, with three groups reported in 2006, rising to five groups in 2014 (Le Trong & Le Minh 2010; Tran Van & Nguyen Dinh 2019). Though the rate of population growth since 2006 appears to be biologically infeasible (157% growth over just 13 years), it does nonetheless suggest that the Che Tao sub-population is currently stable or possibly increasing. Compiling the earlier records from 2000-2001, apparently six groups were recorded from the Che Tao area during this period (Le Trong & Le Minh 2010). This longer time-line of the population suggests that the year 2006 was in fact a low point for the Che Tao sub-population.

The trend for the Na Hang – Muong La sub-population appears to be more obviously negative than the Che Tao sub-population. As many as 22 groups were reported in this area in the 2006 and 2007 surveys, declining to 15 groups in 2010 (Le Trong & Le Minh 2010; Tran Van & Nguyen Dinh 2019). Compiling data from 2000-2001 using different methods, it appears that 33 groups occurred in the Na Hang – Muong La area at that time (Le Trong & Le Minh 2010). Similar to the Che Tao sub-population, it is difficult to be certain about the exact trend given the survey methods used, but the apparent 41% decline since 2006 (or 61% decline since 2001) does at least align with our understanding of the intense pressures that this sub-population has faced. The distribution of the species also appears to have contracted in recent years, with areas in the south of Muong La NR, including Nam Pam commune, now no longer occupied by gibbons. If there is any cause for optimism, it is that the decline appears to have been more moderate in recent years (a loss of 18 groups from 2000 to 2010, compared to 2 groups from 2010 to 2019), suggesting that the fortunes for the gibbons in Na Hang and Muong La could be turned around with a scaled-up injection of conservation resources.

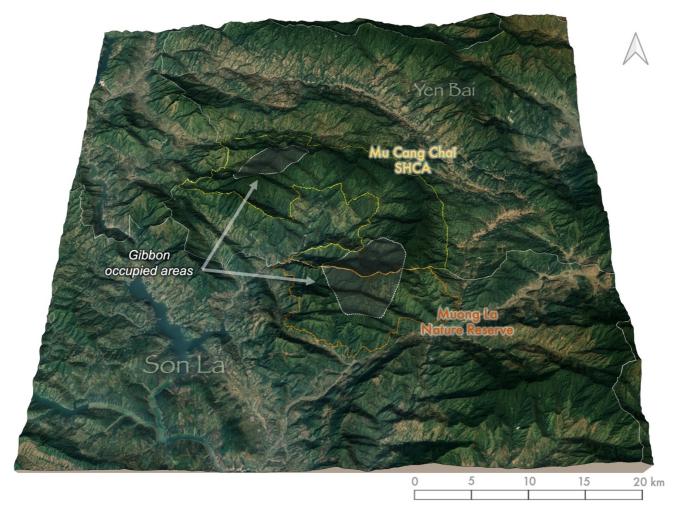


Figure 4. Area occupied by the western black gibbon (*Nomascus concolor*) in Vietnam (dotted white outlines), derived from data collected in the last population survey (Tran Van & Nguyen Dinh 2019). The northern occupied area is referred to as the 'Che Tao' sub-population, whilst the southern area is the 'Na Hang – Muong La' sub-population. The boundaries of the two protected areas are indicated: Mu Cang Chai Species and Habitat Conservation Area (yellow outline) in Yen Bai Province and Muong La Nature Reserve (orange outline) in Son La Province. Basemap shows Airbus satellite imagery for 2023 from Google Earth.

A re-survey of the whole Mu Cang Chai – Muong La population is planned for 2023 using acoustic methods (Trinh-Dinh, H., pers. comm., 2023), offering the potential for a more accurate and robust population assessment than has been possible before. This should serve as an objective basis from which to manage the two sub-populations going forward.

3.4. Estimated population densities

Based on the most recent survey data (Tran Van & Nguyen Dinh 2019), the population occupies an area of 75 km² (24 and 51 km² for the Che Tao and Na Hang – Muong La sub-populations, respectively). This gives a density of 0.25 groups or 0.86-1.06 individuals per km². Alternatively, the combined area of Mu Cang Chai SHCA and Muong La NR is 274 km², meaning that the landscape-level density is 0.07 groups or 0.23-0.29 individuals per km².

Reported western black gibbon densities from China are higher than from Vietnam, with group density inside Wuliangshan National Nature Reserve estimated at 0.44 groups per km² (Yang 2023). However, outside the reserve, where groups are subject to higher threats, densities were 45% lower, at 0.24 groups per km² (Yang 2023). The population density in Vietnam is similar to the density outside protected areas in China.

3.5. Recent research findings

Beyond population surveys, the western black gibbon has not been the subject of any substantial ecological research in Vietnam. Almost all information available about the species comes from long-term intensive studies in China, primarily from an area near the village of Dazhaizi, on the western slope of Wuliang Mountain, Wuliangshan NNR, central Yunnan (e.g. Fan & Jiang 2008a; Fan, Jiang & Tian 2009a; Fan *et al.* 2009c; Huang *et al.* 2013; Hu *et al.* 2018). This work has shown, for example, that a habituated gibbon group at Dazhaizi used a large home-range of 129 ha, and had a highly flexible diet that varied seasonally (Fan & Jiang 2008b; Fan *et al.* 2009b).

The species has also been studied in a highly fragmented site ('Bajiaohe') in southern Yunnan, relatively close to the border with Vietnam. The gibbons in this unprotected site demonstrate the ability of the species to persist in highly disturbed and fragmented forests, so long as they are not hunted. The study group had a very small home-range of just 14 ha and, unusually for *Nomascus* gibbons, fed overwhelmingly on fruit; approximately 75% of feeding records consisted of fruit, compared to 45-50% at the Dazhaizi study site (Ni *et al.* 2014). The dietary flexibility of the species was also underlined by the fact that there was just 5% overlap in the species eaten when comparing the Bajiaohe and Dazhaizi gibbons (Ni *et al.* 2014), suggesting little dependence on any particular species. Relatively little overlap in the diets was also present at the genus and family level (Ni *et al.* 2014).

Western black gibbons have been found to live primarily in polygynous groups in China (Guan *et al.* 2018). For example, all five of the original groups in the 'Dazhaizi' population had two females (Fan *et al.* 2006). This also seems true for the Mu Cang Chai – Muong La population, with 60% and 80% of observed groups containing two females according to the 2010 and 2019 survey data, respectively (Le Trong & Le Minh 2010; Tran Van & Nguyen Dinh 2019).

A population viability analysis of the 'Dazhaizi' sub-population in Wuliangshan NNR found that it was highly susceptible to even low levels of potential poaching pressure, due to an already elevated mortality rate (Fan & Jiang 2007). The small size of the sub-population (just 5 groups) also left it vulnerable to genetic diversity loss and inbreeding, meaning its long-term survival was dependent on restoring and connecting remaining habitat, to allow new groups to form and for genetic exchange among sub-populations. These findings may also hold true for the two remaining sub-populations in the Mu Cang Chai – Muong La landscape.

The western black gibbon lives in some of the highest elevation forests of any gibbon species, between 1,900 and 2,700 m (Guan *et al.* 2018). Ostensibly, this should leave the species highly vulnerable to climate change, as high elevation habitats are expected to undergo shifts towards mountain-tops and therefore shrink in size. However, climate envelope modelling predicted that the western black gibbon may actually see an increase in potential range in the future (Yang *et al.* 2021). In practice, this conclusion is highly dependent on habitat being sufficiently connected, such that gibbons are able to move and track changes in their habitat.

For the western black gibbon, this would require considerable conservation planning and investment of resources in order to establish habitat corridors (Wu *et al.* 2021).

3.6. Knowledge gaps

The western black gibbon remains very poorly studied in Vietnam, with basic information about the species lacking. In particular, information about the diet, ranging behaviour, habitat needs and demographic rates of the population in the Mu Cang Chai – Muong La landscape would be a priority to understand. Such information would improve our understanding of the viability of the population, as well as allow for more effective conservation approaches to be devised vis-à-vis the sustainable use and extraction of resources in the landscape (in particular, timber extraction and cardamom cultivation, which are ongoing at a high rate).

Such a study would have to be undertaken by habituating and following one or more gibbon groups. A pilot study to investigate the feasibility of this was undertaken in Hau De Cha valley. Che Tao, Mu Cang Chai SHCA from April to September 2021 (Fauna & Flora, unpublished data, 2021). Using a community-based monitoring approach, two groups were monitored and preliminary data collected. This revealed the apparently very low calling rate of these two groups (approximately 30% of monitoring days, compared to >40% in China; Jiang et al. 2006) and their relatively small group sizes (3-4 individuals, compared to an average of 6.2-6.4 in China; Fan et al. 2006). Over the 6-month period (10 days monitoring per month), the main focal group ('CT03', consisting of 1 adult male, 2 adult females and 1 juvenile) produced 17 song bouts and was directly observed for 6.4 hours in total. A preliminary (95% kernel density) home-range of 27 ha was calculated (likely a considerable underestimate of the total home-range and more likely relating to the group's use of just one of several valleys they likely occupy). Both groups had areas of cardamom cultivation expanding into their homeranges, which was likely causing a reduction in food resources, as well as an increase in energy expenditure in order to traverse around canopy gaps. This preliminary study showed that, with investment, training and long-term commitment, a study of the western black gibbon in Vietnam would be possible. At least one year would be needed to advance the habituation process sufficiently far to allow for proper data collection to begin. In addition, the protection of habituated groups from hunters would have to be ensured with an increase in patrolling and enforcement efforts in the area.

A second priority knowledge gap for the species in Vietnam would be to undertake an acoustic population survey across the Mu Cang Chai – Muong La landscape. As noted above, there remain considerable uncertainties in the population survey data so far available for the species. Expert-based group counts are likely highly vulnerable to assumptions about calling rates and home-range sizes, both of which are poorly known for the species in Vietnam. An exhaustive acoustic survey of the Mu Cang Chai – Muong La population, covering all available habitat (including previously unsurveyed areas of habitat lying between the two sub-populations), would be highly informative. Ideally, a vocal fingerprinting approach (e.g. Wearn *et al.* 2023a) could be used to improve the accuracy of the population estimates.

3.7. Emerging threats

The threats to the western black gibbon in the Mu Cang Chai – Muong La landscape appear to have evolved since the last status review. At that time, hunting, logging and infrastructure development (roads and hydropower) were noted as the major threats to the species (Rawson *et al.* 2011). One gibbon was known to have been hunted in Muong La in 2010, just

one year before the last review was written (Le Trong & Le Minh 2010). Although gun hunting is ongoing in both PAs, this appears to have declined considerably in the last decade. Gibbon surveys from 2005-2010 recorded an average of 6.8 gunshots day⁻¹ (Le Trong & Le Minh 2010), but the most recent survey recorded just one gunshot during the whole survey, equating to 0.08 gunshots day⁻¹ (Tran Van & Nguyen Dinh 2019). No more cases of gibbon hunting or trade have emerged from the two sites since the case in 2010, although a small number of gun confiscations continue to be made (Fauna & Flora unpublished SMART data, 2021). This is likely due to cultural trends among local communities, as well as stronger enforcement (including gun confiscation) and awareness of laws. At least some of the decline may, however, be due to more cryptic avoidance of authorities by hunters.

Whilst the threat from hunting appears to have reduced, the state of the habitat in both sites has progressively declined and is likely the biggest threat to the population and the biggest constraint on its recovery. Black cardamom - an understorey plant yielding a popular spice used in Vietnamese and Chinese cuisine – was first cultivated in the area from the early 1990's and experienced a boom in production especially since 2005 (Tran Quang et al. 2020). It is now widely cultivated over vast areas of the landscape, including deep inside both protected areas. Initially this was in the lower-elevation areas, away from remaining gibbon groups, but the area of cardamom continues to expand upslope each year and is now heavily encroaching on the gibbon-occupied areas. Although cardamom can be cultivated using lower-impact and more sustainable methods, these are not practiced in the region. Canopy thinning is intensive (leaving just 10-20% canopy cover in some areas), which causes wide canopy gaps and the loss of important food trees. In addition, understorey clearance for planting of the cardamom plants results in a complete cessation of tree recruitment, threatening the long-term survival of the forest itself. This has likely displaced gibbons from some areas, as well as reduced food availability and increased foraging costs (likely with knock-on effects on population viability). Currently practiced methods also involve drying of the cardamom directly in the forest using traditional ovens. These ovens consume vast amounts of wood, further exacerbating forest loss. Human disturbance during the peak harvesting season may also cause gibbons to flee and temporarily lose access to parts of their home-range, perhaps with long-term effects on population health.

Illegal logging of high-value timber, principally *Fokienia hodginsii*, also continues, especially in Mu Cang Chai SHCA (which still contains considerable timber resources). This logging reduces the habitat quality and connectivity for gibbons, opening up canopy gaps that groups must traverse. It also creates considerable human disturbance, affecting the ability for gibbon groups to access critical resources in their home-range. Chainsaws appear to be widely in use inside the protected areas, although confiscations by the FPD (assisted by the community patrol teams) may be having some impact on this (Fauna & Flora unpublished SMART data, 2022).

These ongoing threats to the remaining gibbon habitats in the Mu Cang Chai – Muong La landscape are layered upon decades of previous habitat loss and degradation. This includes inundation of forest areas for hydropower, road construction and upgrading, and burning of the forest (Rawson *et al.* 2011). The result today is a landscape that is rapidly losing its ability to sustain gibbons, even in the absence of further hunting. In Muong La NR, in particular, remaining forest is heavily reduced and fragmented; areas that were burnt are now in an arrested state of succession due to dense cover with ferns. The degradation of the forest also leaves it drier and therefore more susceptible to further forest fires, causing a vicious circle of destruction.

3.8. Conservation management

3.8.1. In-situ conservation

Fauna & Flora has invested considerable resources into the conservation of the western black gibbon in Vietnam since it was 'rediscovered' by conservationists in Mu Cang Chai District in 1999. In close partnership with the government, this has involved gun control, awareness campaigns, community-based patrolling, livelihood initiatives, land-use zoning and the gazettement of Mu Cang Chai SHCA in 2006 (Rawson *et al.* 2011). Since the last status review in 2011, this support has continued, with community patrol teams in Mu Cang Chai and Muong La maintained continuously. Son La PPC also upgraded Muong La to a Nature Reserve in 2016, giving it additional resources and a formal management board (something which Mu Cang Chai SHCA still lacks). In 2019, a national conservation action plan for the species was agreed by district and provincial FPD, Muong La NR and Fauna & Flora (Tran Quang *et al.* 2020). This laid out a comprehensive set of actions for the period 2020-2025, including a longer-term vision for the species until 2050.

3.8.2. Ex-situ conservation

No institutions in Vietnam have captive western black gibbons, certainly not breeding populations. This species also does not appear to be represented in international zoos. There is therefore no ex-situ contribution to the conservation of the species currently.

3.8.3. Policy

The western black gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. It was listed as Endangered in Vietnam's national Red Data Book (VAST 2007).

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) control the possession and use of firearms; 2) support the designation of Muong La NR; 3) develop village-level regulations for natural resource use (including forest clearance, degradation and hunting); 4) reduce the impacts of fuelwood collection through fuel-efficient stoves and plantations; 5) support community-based patrolling, including through channelling of PFES payments, and 6) ensure coordination between management authorities of Mu Cang Chai SHCA and Muong La NR. To date, we are not aware of any specific activities or budget tied to these actions (La Quang & Le Khac 2020), although Fauna & Flora continues to support the two protected areas to undertake most of the priority actions. Most significantly, community-based patrolling has been maintained inside the two PAs and Fauna & Flora is facilitating a sustainable finance mechanism to invest a percentage of PFES funds to fund the patrolling (Action point 5). This is part-operational in Muong La NR, where 50% of the community patrol costs are so far covered by PFES (Le Hai, Y., pers. comm., 2023). Awareness-raising around the illegality of possessing firearms continues, as well as gun amnesty events (Action point 1). Muong La was successfully upgraded from a watershed protection forest to nature reserve in 2016 and continues to be supported technically and financially by Fauna & Flora (Action point 2). A large number of fuel-efficient 'ecostoves' have been distributed to local communities, which can reduce fuelwood consumption by around 50% (Action point 4). Fauna & Flora has also convened meetings (including the action planning workshop in 2019) between the two PAs (Action point 6).

Northern white-cheeked gibbon

(Nomascus leucogenys)

Image: © Staffan Widstrand

Fast facts:

- Found across five provinces in Vietnam, from Dien Bien in the north to Ha Tinh in the south
- Local populations mostly small, isolated and under pressure from hunting and habitat loss or degradation; high number of population extinctions in recent decades
- Strongholds in: Pu Mat NP (400+ groups estimated), the contiguous Xuan
 Lien Nature Reserve Pu Hoat Protection Forest (128 groups), and Vu
 Quang NP (185 groups estimated)
- Some protections conferred on its stronghold populations (in particular Pu Mat NP) but elsewhere dedicated conservation actions are lacking
- Significant national and international ex-situ holdings of the species exist, but reintroductions from captivity likely difficult
- Priority is to protect existing populations by preventing hunting and trade, allowing recovery over the long-term

4. Northern white-cheeked gibbon (*Nomascus leucogenys*)

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Summary

- The northern white-cheeked gibbon (*Nomascus leucogenys*) was originally distributed across a broad swathe of northwest and central Vietnam, but is today only found in a small fraction of this area, mostly in small and isolated populations along the Vietnam-Laos border
- Despite numerous local population extinctions in recent decades, major strongholds for the species remain in: Pu Mat National Park; the contiguous forests of Xuan Lien and Pu Hoat (Nature Reserve and Protection Forest, the latter lying outside the protected area network), and Vu Quang National Park
- Substantial stretches of unsurveyed and apparently suitable habitat exist along the border with Laos in Nghe An and Ha Tinh provinces; the status of any gibbon populations that might be present in these areas, which lie outside the protected area network, represents a key knowledge gap for the species
- Population densities appear to be depressed everywhere, due to hunting, the loss or degradation of habitat, or the effects of population isolation; with protections in place, some of these populations may recover slowly
- Due to a lack of demographic and genetic data, it remains difficult to assess the viability of populations, although the smallest (<10 groups) are unlikely to be viable in the long-term without intensive management
- The species is subject to relatively little conservation attention; only in Pu Mat NP, Xuan Lien NR and Pu Hoat (NR and PF) has a committed approach been adopted, with NGOs working closely with PA management boards
- Unlike other gibbon species, significant holdings of the species exist ex-situ, both within Vietnam and internationally; however, it will be challenging to release captive gibbons successfully back into the wild (especially captive-born individuals)
- With apparent population declines in Laos and extinction of the species in China, the future of the species increasingly lies with Vietnam, where remaining populations must be urgently protected and, over the long-term, allowed to recover

4.1. Distribution

The northern white-cheeked gibbon extends over a wide latitudinal range north-to-south in Vietnam, from Dien Bien Province in the far north to approximately the Ha Tinh – Quang Binh border area in central Vietnam (**Fig. 5**). Although the eastern range limit of the species was likely to have originally been as far as the Black (or Da) River, most populations today cling to the border areas with Laos, where the relative inaccessibility of upland forests has allowed populations to escape the worst effects of habitat loss and hunting. The distribution of the species is also highly fragmented, with only three strongholds remaining: i) Pu Mat NP and adjacent unprotected forests in southern Thuong Duong and Thanh Cuong districts; ii) the

contiguous forest block of Xuan Lien NR, Pu Hoat PF and Pu Hoat NR, and iii) Vu Quang NP, along with unprotected forests to the north ('Huong Son forest') and south.

Previous to the 2011 gibbon status review, considerable work was done to survey northern white-cheeked gibbon sites (Rawson *et al.* 2011), as well as to refine the boundaries between gibbon taxa using genetic and acoustic data (Van Ngoc *et al.* 2010d, 2011). This expanded the known distribution of the species at the time, but uncertainties around the exact southern limit of the species remain. The hypothesis proposed was that the Gianh River in Quang Binh Province (also called the Rao Nay River after the names of the headwaters) was the dispersal barrier between the northern and southern white-cheeked gibbons. This river runs between the Ke Go – Khe Net complex and Khe Ve proposed NR (Minh Hoa SFE), meaning the former is occupied by *N. leucogenys* and the latter *N. siki* (Van Ngoc *et al.* 2010d; Rawson *et al.* 2011). This hypothesis has not been explored with new data since 2011 and the species boundaries between the northern and southern white-cheeked gibbons remain uncertain, especially in the hinterlands of the Vietnam-Laos border.

The northern white-cheeked gibbon also occurs in Laos, where it was assumed to have a relatively large distribution and healthy populations in some areas (Duckworth 2008; MAF 2011; Rawson *et al.* 2011). However, intense threats have been reported from across the country, including hunting for traditional medicine and consumption, and collection for the pet trade (Duckworth 2008). As a result, recent surveys in purported strongholds have revealed depressed populations, for example in Nam Et-Phou Louey NPA (57 groups; Syxaiyakhamthor *et al.* 2020), Phou Den Din NPA (10 groups; Thipphavong 2015) and Nam Kading NPA (approximately 265 groups, after excluding *N. siki* groups; Hallam *et al.* 2016).

The species also appears to occur in the very large (3,532 km²) Nakai-Nam Theun NPA in Laos, where gibbon densities are reportedly high (Nanthavong 2013). Previously, this site was often assumed to be host to *N. siki* (e.g. MAF 2011; Rawson *et al.* 2011), but preliminary results from a study of the acoustic and genetic characteristics of gibbons from across the site suggest that both species, *N. siki* and *N. leucogenys*, are in fact present (Coudrat 2023). The Nam Theun-Nam Kading river that bisects the park may be at least a partial dispersal barrier for gibbons, with gibbon songs north of the river corresponding more closely to *N. leucogenys* and those from south of the river corresponding to *N. siki* (Coudrat 2023).

Historically, the northern white-cheeked gibbon occurred in China also, but here too the species suffered from hunting and habitat loss; it is now extinct in the wild in China (Fan, Fei & Luo 2014; Fan 2017). A small number of individuals have been reintroduced to 'Wild Elephant Valley' in Xishuangbanna (Yunnan Province), although they are regularly provisioned with food (Fan P. F., pers. comm., 2023). Given the poor status of the species in neighbouring Laos and China, a renewed focus for the conservation of the species is now on Vietnam.

4.2. Population status

There appear to be three main strongholds remaining for the species in Vietnam:

- i) Pu Mat NP
- ii) a forest complex composed of Xuan Lien NR, Pu Hoat PF and Pu Hoat NR
- iii) Vu Quang NP, contiguous with Nakai-Nam Theun NP in Laos

The largest population appears to be in Pu Mat National Park, as was already identified in the last review (Rawson et al. 2011). Recent surveys (2019-2020) recorded 46 gibbon groups from 18 listening post arrays (54 listening posts in total) spread systematically across the park (Wearn et al. 2021a). Using spatially explicit capture-recapture (SECR) analysis, the total population size for the park was estimated at 429 family groups (95% confidence interval: 278 to 580 groups), making it the largest northern white-cheeked population so far quantified in Vietnam and indeed globally (Wearn et al. 2021a). Conservatively assuming population sizes of 3.5 individuals per group, the park may be home to >1500 gibbons (Wearn et al. 2021a). The estimate accounted for the fact that areas in the north-west of Pu Mat NP were found to be largely devoid of gibbons, likely due to hunting by local communities. Previously, it was thought that an estimated 130 family groups (95% confidence interval: 120 to 175) inhabited Pu Mat NP (Luu Tuong & Rawson 2011), but these methods arbitrarily assumed an effective listening radius of 1.5 km. This distance is likely an overestimate, with many groups being missed beyond 1 km distance (Wearn et al. 2021a), leading to an underestimate of the total number of gibbons in the park. Even so, future surveys in Pu Mat NP would benefit from the use of acoustic recordings, from which gibbon groups can be individually identified (e.g. Wearn et al. 2023a), to help validate existing population estimates.

Pu Mat NP is also bolstered to the north and south by adjoining, unprotected forests that appear to contain suitable habitat for gibbons (Khoa Van *et al.* 2023). To the west, adjoining forests in the Nam Chouane-Nam Xang biodiversity offset area in Laos may also harbour gibbons.

Recent surveys in Vu Quang NP, also using robust methods, have similarly uncovered a large population of northern white-cheeked gibbons in Vu Quang NP. This park previously represented a major knowledge gap for the species, but surveys across 40 listening posts throughout the park in 2020 detected a minimum of 19 groups (Tran Van 2021). Using distance sampling analysis, and correcting for groups that might have been missed because they did not call, the total population size for the park was estimated at 185 groups (95% confidence interval: 78 to 448 groups). The population in Vu Quang NP is now the second largest estimated population in Vietnam (albeit with the caveats mentioned in the next paragraph). The newly-recognised importance of the park should lead to greater attention and resources being devoted to managing its gibbon population. The population in Vu Quang NP is also bolstered by forests to the north and south that appear to contain suitable habitat (Cao Phan *et al.* 2021), but which remain unsurveyed for gibbons. Vu Quang NP is also connected to northern Nakai-Nam Theun NPA, thought to be host to a large *N. leucogenys* population (although this remains to be confirmed genetically).

Surveys in other sites using robust methods (SECR or distance sampling) have not yet been done, making it difficult to make direct comparisons with the estimates from Pu Mat NP and Vu Quang NP (**Table 4**). In general, we would expect the robust methods to yield higher estimates for a given site than approaches that simply attempt to count the number of gibbon groups, because the latter approach usually cannot feasibly visit all areas within a site and will therefore miss many groups. Nonetheless, recent surveys in the contiguous forests of Xuan Lien NR and Pu Hoat PF have uncovered more significant populations in this area than previously thought. Surveys in 2019 counted 64 gibbon groups each in Xuan Lien NR and Pu Hoat PF (Nguyen Manh 2020). Surveys in nearby Pu Hoat NR, apparently connected to Pu Hoat PF by a narrow corridor of disturbed forest, were only able to confirm three groups (Nguyen Manh 2020). Large areas of northern Pu Hoat NR, where suitable habitat appears to exist, remain to be surveyed.

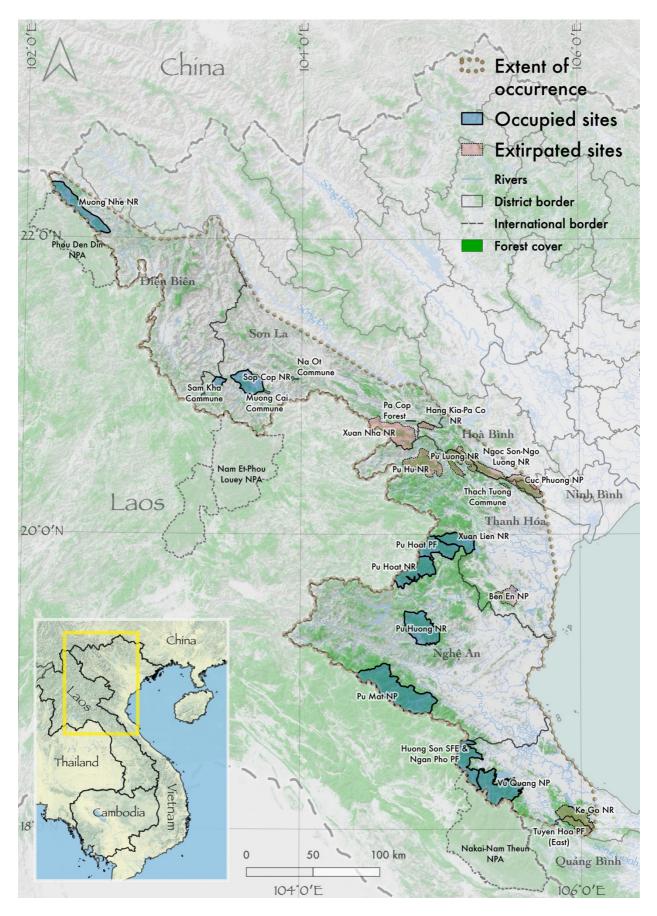


Figure 5. Extent of occurrence of the northern white-cheeked gibbon (*Nomascus leucogenys*) in Vietnam. Key populations are in: Pu Mat National Park; Vu Quang National Park, and the contiguous forests of Xuan Lien Nature Reserve, Pu Hoat Protection Forest and Pu Hoat Nature Reserve. Forest cover for 2022 was extracted from the Global Forest Change dataset (Hansen *et al.* 2013). Protected areas in Laos that connect with sites in Vietnam are also shown.

The combined population of 131 groups in the Xuan Lien – Pu Hoat (PF and NR) complex is of the same order of magnitude as the populations in Pu Mat NP and Vu Quang NP (i.e. in the 100's) and, although the methods used preclude the calculation of group density, the high number of groups heard may indicate a dense population. Indeed, the population may turn out to be larger than that in Vu Quang or Pu Mat NPs once a full assessment is made using robust methods. Pu Hoat PF remains outside Vietnam's protected area network, potentially exposing these gibbons to hunting and habitat disturbance. These new results represent a substantial increase on previous surveys, which recorded 10-12 groups in the Xuan Lien – Pu Hoat complex (Rawson *et al.* 2011), and dramatically changes our view of the conservation importance of this landscape.

There are at least three very small and isolated northern white-cheeked gibbon populations that persist in Son La Province. Two groups were reported from Van Ho District during the last status review on the basis of interview data (Rawson et al. 2011) and these have now been confirmed in the field (Trinh Le, N., pers. comm., 2023). These groups are now being monitored by local communities with the support of PanNature. Similarly, a group was reported in the last status review from Muong Cai Commune, Song Ma District, and recent information suggests that this group (and possibly up to four groups) persists in this area (Nguyen Dinh, D., pers. comm., 2023). In Na Ot Commune, Mai Son District, a very small population has been reported recently for the first time, with a full survey yet to be completed (Trinh Le, N., pers. comm., 2023). The long-term prognosis for these isolated groups in Son La Province is rather pessimistic, given the high chance of inbreeding and genetic diversity loss with so few individuals. Nonetheless, these populations have survived for another decade, whilst small populations in other locations have disappeared. These are also rare cases of community-championed gibbon conservation in Vietnam, where gibbons have survived near to villages and are a source of local pride (as Rawson et al. 2011 noted for Muong Cai Commune). Such conservation efforts should not only be supported but also examined for any broader lessons that might be learned for gibbon conservation in Vietnam.

Populations elsewhere in the northern white-cheeked gibbon's range in Vietnam have not been surveyed since the last review in 2011 (**Table 4**). This includes: the ostensibly small population in the far north of Vietnam in Muong Nhe NR (contiguous with Phou Den Din National Protected Area in Laos); the isolated group in Sam Kha Commune, Sop Cop District; the isolated population on Pu Huong mountain in Pu Huong NR, and the potentially significant population in Huong Son forest (contiguous with Vu Quang NP). Anecdotally, it appears that the populations in Muong Nhe and Pu Huong NRs have declined in recent years, ostensibly due to hunting and other pressures (Nguyen Manh, H., pers. obs., 2023).

For other small or data deficient populations that were reported by Rawson et al. (2011) – including in Hang Kia-Pa Co NR, Xuan Nha NR, Ngoc Son-Ngo Luong NR, Pu Luong NR, Pu Hu NR, Ben En NP and Ke Go NR – we are not aware of any new reports and assume that these populations have all been lost by now. This also applies to Khe Net proposed NR (i.e. the eastern section of Tuyen Hoa PF), for which recent surveys again failed to detect gibbons (Le Trong *et al.* 2021). If credible new information surfaces from any of these sites, a resumption of conservation actions may be warranted, with the proviso that the long-term viability of any remnant groups is likely to be low. For Ke Go NR, any future surveys will need to account for the fact that it has been host to releases of gibbons confiscated from the illegal wildlife trade (Nguyen Manh, H., pers. obs., 2023).

Table 4. Northern white-cheeked gibbon (*Nomascus leucogenys*) sites in Vietnam since 2000.

Site	Province	Area (ha)	Survey year	Recorded # groups	Estimated # groups	Group density, per km²	Survey methods	Change since last assessment	Source
Muong Nhe NR ^a	Dien Bien	45,581	2010	16	-	-	Listening post survey	-	Nguyen Manh <i>et al.</i> 2010a
Sai Khao Village, Muong Cai Commune, Song Ma District	Son La	300	2023	1	-	-	Interviews	Recognised here as distinct from Sop Cop NR; unconfirmed reports of up to 4 groups	Nguyen Dinh D., pers. comm., 2023
Sop Cop NR	Son La	17,406	2023	1	-	-	Recce surveys	Gibbons were previously thought to have been extirpated from this site	Nguyen Dinh D., pers. comm., 2023
Sam Kha Commune, Sop Cop District (Sop Cop NR buffer zone)	Son La	300	2011	1	-	-	Listening post survey	-	Rawson <i>et al.</i> 2011
Na Ot Commune, Mai Son District	Son La	700	2023	1	-	-	Interviews	Newly-added as a confirmed gibbon site	Trinh Le N., pers. comm. 2023
Pa Cop Forest, Van Ho Commune, Van Ho District ^b	Son La	630	2023	2	-	-	Direct observation	2 groups were reported from interviews in 2011; these groups have now been confirmed in the field	Trinh Le N., pers. comm. 2023
Hang Kia-Pa Co NR	Hoa Binh	7,091	2009	Extirpated	-	-	Listening post survey	-	Rawson <i>et al.</i> 2011
Xuan Nha NR	Son La	16,317	2011	Extirpated	-	-	Listening post survey	-	Rawson <i>et al.</i> 2011
Ngoc Son-Ngo Luong NR	Hoa Binh	19,254	2009	Extirpated	-	-	Interviews and field surveys	Confirmed extirpated	Cano & Tellería 2013
Pu Luong NR	Thanh Hoa	17,662	2008	Extirpated	-	-	Interviews and field surveys	-	Rawson <i>et al.</i> 2011
Pu Hu NR	Thanh Hoa	27,503	2008	Extirpated	-	-	Interviews and field surveys	-	Rawson <i>et al.</i> 2011

Thach Tuong Commune, Thach Thanh District	Thanh Hoa	1,000	1999	Extirpated	-	-	Interviews	Presumed extirpated given lack of gibbon records for > 20 years	Geissmann <i>et al.</i> 2000
Cuc Phuong NP	Hoa Binh, Ninh Binh, Thanh Hoa	22,408	1993	Extirpated	-	-	Interviews		Geissmann <i>et al.</i> 2000
Xuan Lien NR	Thanh Hoa	23,816	2020	64	-	-	Listening post survey	Recorded # groups increased from 7 (survey in 2007)	Nguyen Manh H., pers. comm., 2023
Pu Hoat NR	Nghe An	36,226	2020	3	-	-	Listening post survey	Recognised as distinct from Pu Hoat PF	Nguyen Manh H., pers. comm., 2023
Pu Hoat PF	Nghe An	54,475	2020	64	-	-	Listening post survey	Recognised as distinct from Pu Hoat NR; Recorded # groups increased from 10 (survey in 2010)	Nguyen Manh H., pers. comm., 2023
Ben En NP including buffer zone	Thanh Hoa	15,800	2020	Extirpated?	-	-	Interviews and field surveys	Presumed extirpated in the park, although groups may remain in buffer zone (only 2-3 groups reported in 2009)	Rawson <i>et al.</i> 2011; Nguyen Manh H., pers. comm., 2023
Pu Huong NR	Nghe An	50,075	2021	2	-	_	Listening post survey	7 groups were recorded for Pu Huong NR in 2009; local reports suggested 6 groups in 2021 (2 were confirmed in the field during a short survey)	Luu Tuong & Rawson 2009; Khoa Van & Thanh Hai 2021
Pu Mat NP	Nghe An	91,113	2020	46	429 (95% CI: 278- 580)	0.48 (95% CI: 0.31- 0.65)	Spatially explicit capture- recapture	Recorded and estimated # groups increased from 22 and 130, respectively (survey in 2011)	Wearn <i>et al.</i> 2021
Huong Son SFE & Ngan Pho PF	Ha Tinh	38,000	2011	4	-	-	Interviews and field surveys	Listed as 'Huong Son forest' in the previous review	Rawson <i>et al.</i> 2011
Vu Quang NP	Ha Tinh	55,274	2020	19	185 (95% CI: 78- 448)	0.33 (95% CI: 0.14- 0.81) ^c	Distance sampling from	Recorded # groups increased from 10 (survey in 2011)	Tran Van D., pers. comm. 2023

							listening posts		
Ke Go NR⁴	Ha Tinh	21,759	2010	Extirpated?	-	-	Listening post survey	Now considered provisionally extirpated (4 groups reported in 2010)	Van Ngoc <i>et al.</i> 2010a; Nguyen Dinh D., pers. comm., 2023
Tuyen Hoa (East) PF (Khe Net proposed NR) ^d	Quang Binh	23,534	2020	Extirpated	-	-	Listening post survey	Confirmed again as extirpated (last surveyed in 2010)	Le Trong <i>et al.</i> 2021
Huong Khe PF ^e	Ha Tinh	31,000	-	?	-	-	-	Newly-added as a potential gibbon site; contiguous with Vu Quang NP	
Tuyen Hoa (West) PF (part of Khe Ve proposed NR) ^e	Quang Binh	12,815	2021	2	-	-	Listening post survey	Newly-added as a confirmed gibbon site	Le Trong <i>et al.</i> 2021
Minh Hoa PF (overlaps with Giang Man proposed NR) ^e	Quang Binh	60,000	2020	6	-	-	Listening post survey	5 groups were recorded for Giang Man proposed NR in 2004	Le Trong <i>et al.</i> 2021
			groups periods)	224	773				
		recer	roups – it only 2011)	203	752				

^a*N. concolor* was also provisionally reported from this site but this needs confirmation with acoustic and genetic data.

^bThis population was reported from Long Luong Commune, Moc Chau District in the last status review, but now sits administratively in a different district and commune. ^cReported densities from this study of 0.74 groups per km² (within the surveyed areas) were recalculated by dividing the estimated number of groups by the area of the park to allow fairer comparisons.

^dSites which are here assumed to harbour *N. leucogenys* but warrant confirmation from further acoustic and genetic data.

^eSites (in grey text) which are considered more likely to be *N. siki* than *N. leucogenys* but are here tentatively included because this remains to be confirmed genetically. These sites are not included in the totals.

4.3. Population trends

Due to differing survey methods over time, it is not possible to robustly assess population trends over time in any northern white-cheeked gibbon site. In Pu Mat NP, it may be the case that protections put in place, especially over the last decade, have led to modest population recovery in localised areas of the park, such as in the Khe Choang Intensive Protection Zone (IPZ). Gibbons are absent or occur at low density in other parts of the park, however (Wearn *et al.* 2021a), suggesting that recovery still has a long way to go. The population in Xuan Lien – Pu Hoat may also have increased in some localised areas in recent years, although this is conjectural. In all other sites, populations have likely undergone declines in recent years or, in a smaller number of cases, remained stable (such as in Van Ho and Muong Cai communes).

4.4. Estimated population densities

Population densities for the northern white-cheeked gibbon have only been estimated at two sites in Vietnam thus far: Pu Mat NP (Wearn *et al.* 2021a) and Vu Quang NP (Tran Van 2021). In Pu Mat NP, historical (and, in some areas in the north-west, recent) hunting means that populations are likely depressed from the habitat's carrying capacity. Nonetheless, population density was estimated at 0.48 groups per km². In Vu Quang NP, densities were estimated at 0.33 groups per km² (after being recalculated for the whole park), also indicating a population depressed by hunting pressure.

The two available estimates from Vietnam are similar to a density estimate for northern whitecheeked gibbons from a site in Laos, located near the border with Vietnam. In the western section of Nam Et-Phou Louey NPA, densities were estimated at 0.40 groups per km² (Syxaiyakhamthor *et al.* 2020). In mixed deciduous forest, where hunting pressures were lower, densities reached 0.74 groups per km².

Densities at another site subjected to hunting in Laos – Nam Kading National Protected Area – were estimated to be even lower, at 0.24 groups per km² (Hallam *et al.* 2016). The data included some *N. siki* groups (which co-occur in the site), though the densities of the two species were not found to differ. The population appears to have undergone a decline since the 1990s and is expected to slowly recover with more effective management of the site (Hallam *et al.* 2016).

Further south in Laos, gibbon densities in a 120 km² section of Nakai-Nam Theun NPA were estimated to be high, at 2.7 groups per km² (Nanthavong 2013). Although the taxonomic status of the gibbons in this site remains unresolved, preliminary results suggest that the Nam Theun river represents at least a partial dispersal barrier between *N. leucogenys* and *N. siki* (Coudrat 2023). The area surveyed by Nanthavong (2013) was north of the Nam Theun river, suggesting that the surveyed population corresponds to *N. leucogenys*. Future surveys in this site (as elsewhere) might benefit from a 'vocal fingerprinting' approach applied to acoustic data (e.g. Wearn *et al.* 2023a) in order to help validate the high density estimate.

4.5. Recent research findings

The northern white-cheeked gibbon has apparently never been the subject of any long-term research in Vietnam. This may reflect the difficulty of finding populations that have not been heavily hunted, and therefore are less wary of humans. It also reflects the rugged terrain

inhabited by the remaining populations of the species (mostly along the Vietnam – Laos border). Fauna & Flora made preliminary attempts to study 2-3 focal groups in Pu Mat NP in 2020, but the terrain and lack of vantage points made direct observations difficult.

In Nam Kading NPA, central Laos, three northern white-cheeked gibbon groups were studied in detail for 12 months (Ruppell 2013). Local taboos on hunting gibbons apparently conserved gibbons in this site, even when other primate species had largely been extirpated. This intensive study revealed a surprisingly high rate of folivory (69% of feeding observations), in fact amongst the highest reported to date for any gibbon population (Ruppell 2013; Guan et al. 2018). However, when fruit was available (primarily at the end of the dry season in this site), it was readily consumed and comprised nearly 50% of feeding observations. Figs made up a relatively small percentage of food items, just 4% of feeding observations, compared to >40% as seen in the more southerly gibbons, such as Hylobates lar (Ruppell 2013). Other aspects of the seasonal ecology of the studied groups were more typical of other gibbon species, such as the social monogamy (all groups contained male-female adult pairs) and the reduced day range and time spent travelling during periods of folivory compared to frugivory (presumably an adaptation to conserve energy when feeding on relatively nutritionally poor leaves). The average day range was 1.5 km and the home-range size was 38 ha (ranging between 29 and 44 ha across the three groups). The home-range size is similar to that reported for *N. gabriellae* (Kenyon 2007; Bach Thanh et al. 2020), as well as other gibbon species (e.g. Hylobates) inhabiting aseasonal forests (Bartlett 2007; but see Cheyne et al. 2019), but considerably smaller than the home-ranges of >100 ha reported for the more northerly Nomascus species, N. concolor and N. nasutus (Guan et al. 2018).

A *Nomascus* population in Nakai-Nam Theun NPA, assigned provisionally to *N. leucogenys* (see *Estimated population densities* section, above), was also the focus of a study of singing behaviour (Nanthavong 2013; Coudrat *et al.* 2015). Gibbons were found to sing for a relatively concentrated period slightly before and after sunrise, and the timing of their calls shifted to track sunrise throughout the year (Nanthavong 2013; Coudrat *et al.* 2015). During warmer days, groups started singing slightly earlier relative to sunrise, but they actually sang more frequently in the colder periods of the year (Coudrat *et al.* 2015).

Despite the two studies in Laos (as well as an early study in China; Hu, Xu & Yang 1990), the northern white-cheeked gibbon remains very poorly studied in the wild, even when compared to other *Nomascus*. This is especially surprising given its relatively common occurrence in international zoos (with approximately 100 individuals in accredited zoos; see *Ex-situ* section, below).

4.6. Knowledge gaps

The status of the northern white-cheeked gibbon in various unprotected forests within its range remains a key knowledge gap. These unprotected forests, in particular along the Laos border in Nghe An and Ha Tinh provinces, contain large swathes of apparently suitable habitat (Cao Phan *et al.* 2021; Khoa Van *et al.* 2023). In Nghe An alone, species distribution modelling identified > 350 km² of high suitability habitat for the species that is outside the protected area network (Khoa Van *et al.* 2023). With just a handful of large, viable populations of northern white-cheeked gibbon remaining in Vietnam (and indeed globally), uncovering a significant number of gibbons in these neglected border areas would be an important finding and could lead to greater attention and resources devoted to managing these populations. Specifically, population surveys are needed in the SFEs surrounding Pu Mat NP (Tuong

Duong and Thanh Chuong districts), as well as in Huong Son SFE and Huong Khe PF, both adjoining Vu Quang NP.

There are some very small populations (<10 groups) of northern white-cheeked gibbon in various locations, primarily in Son La Province. Other remnant populations not mentioned here may also exist and have been overlooked. The long-term viability of such populations is likely poor, given the high chance of genetic diversity loss and inbreeding, as well as vulnerability to stochastic events and unforeseen catastrophes (e.g. disease). Nonetheless, with demographic and genetic data from these populations (from focal group follows and analysis of faecal DNA, respectively), it would be possible to assess their long-term prospects more quantitatively and, more importantly, to decide amongst potential management options. For example, one option might be to translocate lone, isolated groups into a large and well-protected habitat where other remnant groups still exist, boosting the genetic health of the receiving population. Another option might be to manage them for their educational and cultural values, and as 'insurance' populations in case of extinctions elsewhere.

The geographic range limits of the northern white-cheeked gibbon also represents an ongoing knowledge gap, despite considerable work that was done before the last review to help resolve this (Van Ngoc *et al.* 2010d, 2011). In particular, the southern extent of the species may be in Vu Quang NP or it may be in the Ke Go – Khe Net forest block. Preliminary acoustic data suggested that the Ke Go NR gibbons were *N. siki* (Van Ngoc *et al.* 2010a). At the northern end of the distribution, in Muong Nhe NR, the species may be sympatric with the western black gibbon (*N. concolor*). Surveys in 2010 reported hearing western black gibbon calls and local people reported that some gibbons were entirely black (Nguyen Manh *et al.* 2010a). If the two species are indeed sympatric in this site, they may also have naturally undergone some degree of hybridisation.

4.7. Emerging threats

With the northern white-cheeked gibbon having lost so much of its former range in recent decades (**Fig. 5**; **Box 2**), the threats to the populations which remain are, somewhat paradoxically, declining. Population losses have led to a compression of remaining populations into remote and rugged montane habitats, which are offered *de facto* protection purely because of their relative inaccessibility to hunters.

A key site that remains under threat, however, is the Pu Hoat Protection Forest. This area was originally proposed for protection as part of Pu Hoat NR, but was ultimately excluded during gazettement. Although it is ostensibly managed by the Pu Hoat NR management board, it remains outside the formal protected area network. Pu Hoat PF is managed for its watershed function, which typically means that maintenance of forest cover is of primary concern and the protection of biodiversity values is of lower priority. Hunting is apparently ongoing in this area (Nguyen Manh H., pers. comm., 2023).

Although quantitative data are lacking, hunting pressures in other areas appear to be declining. Anecdotally, protections in parts of Pu Mat NP (specifically, in the Khe Choang IPZ, covering 130 km²) have, for example, improved in the last decade, with local people reporting that gibbon hunting and trade declined rapidly between 2000 and 2010 (Nguyen T. / Fauna & Flora, unpublished data, 2021). In other areas of Pu Mat NP, specifically in the north-west (Tam Hop Commune), hunting may persist as a significant threat to any remaining gibbons, with survey teams in 2020 reporting hearing gunshots and few, if any, gibbons in this area

(Wearn *et al.* 2021a). In many areas, hunting may also be gradually declining as communities become less dependent on forests for their livelihoods, and where young adults in rural areas are increasingly migrating to towns and cities for work, instead of learning their craft as hunters.

4.8. Conservation management

4.8.1. In-situ conservation

Since 2016, Fauna & Flora has focussed on the conservation of the northern white-cheeked gibbon in Pu Mat NP. This remains the only long-term conservation project for the species in Vietnam. The project has primarily focussed on community-based monitoring and mitigation of threats, including dismantling of hunting camps and reporting illegal activity in SMART. This is designed to complement the patrolling done by NP rangers. Awareness has also been raised through village meetings, and livelihoods support has been provided to communities living inside Pu Mat NP. Fauna & Flora is also working with the park and other government authorities to design and implement a formal crime prevention strategy. Monitoring of gibbon occupancy in two Intensive Protection Zones is also being done to obtain an accurate picture of where the gibbon 'hotspots' are to inform protection measures, and to measure the impacts of the project over time. This monitoring of gibbon occupancy is relatively simple to implement and complements the more infrequent and expert-led, park-wide gibbon population surveys. Save Vietnam's Wildlife (SVW) are also highly active in Pu Mat NP, although not focusing on gibbons. SVW 'anti-poaching' teams patrol extensively across the park, serving as a deterrent to any potential gibbon hunters and dismantling hunting camps.

CCD have recently provided much-needed technical support to the management boards of Xuan Lien NR, Pu Hoat PF and Pu Hoat NR, with training in biodiversity monitoring, including gibbon survey methods, as well as outreach and educational work. Awareness-raising events in local villages were held, focussing on the northern white-cheeked gibbon, and discussions were brokered between Xuan Lien and Pu Hoat NRs on the topic of transboundary conservation of the gibbon population, which spans Thanh Hoa and Nghe An provinces. CCD is also working with Vu Quang NP to: setup a long-term monitoring programme for gibbons and other threatened wildlife; identify conservation measures to ensure the long-term survival and recovery of the gibbon population in the park and adjacent forests (Huong Son SFE and Huong Khe PF), and raise public awareness about local wildlife.

The northern white-cheeked gibbon occurs in six main protected areas, ranging from National Parks to Nature Reserves. This confers some level of protection on these populations from deforestation, illegal timber extraction and hunting. However, as far as we are aware, no PA has a project focussed on conserving the northern-white cheeked gibbon, nor specific management targets and actions relating to the species. The National Primate Action Plan (NPAP) for 2017-2025 does provide top-down pressure from senior government to protect the species, but due to the limited resources and capacity available for protected area management, as well as a lack of clear prescriptions at the site-scale within the NPAP, no local-scale interpretation of the NPAP has thus far been made.

4.8.2. Ex-situ conservation

The northern white-cheeked gibbon is the most well-represented species of *Nomascus* in zoo collections internationally. For example, the American and Australian zoo associations report

a total of 69 and 18 individuals, respectively (H. Thompson, pers. comm., 2023), with a small number of individuals also known to be housed in unaccredited zoos. This ex-situ population is primarily managed to facilitate research on the species and to assist with conservation education of zoo visitors. Population genetic diversity is reportedly good, but marginally below the target of 95% (Australian population = 89%; American population = 94%). The Australian population has just 12 founders and, although genetic diversity is currently stable, a target of 20 founders has been set. In addition, reliable and consistent breeding has proven difficult for the Australian population. The release of captive individuals into wild or semi-wild settings is recognised as desirable, but no plans are currently in place (H. Thompson, pers. comm., 2023).

In Vietnam, seven individuals are housed in the Endangered Primate Rescue Center (EPRC), in Cuc Phuong National Park. This includes one breeding pair with two offspring. Over the long-term, the EPRC plans to establish a robust breeding programme for the species, with the explicit aim of releasing individuals into the wild (E. Schwierz, pers. comm., 2023). A small number of northern white-cheeked gibbons are also held in Me Linh Station, bordering Tam Dao National Park (Ziegler *et al.* 2016). Other individuals are held in government-run rescue centres (e.g. in Pu Mat National Park), as well as small private zoos (e.g. Hoi An River Safari), often with poorer welfare standards due to limited resources and capacity. One captive individual is also currently held by Vu Quang NP (Nguyen Manh H., pers. obs., 2023).

Ex-situ northern white-cheeked gibbons also exist in the other range countries for the species, Laos and China. Four individuals are housed in the Laos Conservation Trust for Wildlife, north of Vientiane, with releases in the early planning stage, potentially of a gibbon pair (J. Phan, pers. comm., 2023). In China, the species is known to be held in the "Wild Elephant Valley", in Mengyang Nature Reserve (Fan P. F., pers. comm., 2023). Several individuals live semi-wild, dependent on regular provisioning, whilst other individuals are captive in cages. The provenance of these gibbons is unknown and a robust plan for their management is needed (Fan & Huo 2009).

4.8.3. Policy

The northern white-cheeked gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. It was listed as Endangered in Vietnam's national Red Data Book (VAST 2007).

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) identify and protect the key populations of the species within the protected area network; 2) control the possession and use of firearms in and around protected areas; 3) engage local communities living alongside the species in conservation and raise their awareness; 4) assess the status of populations in undersurveyed areas, and 5) develop transboundary conservation mechanisms across the Vietnam – Laos border. To date, we are not aware of any specific activities or budget tied to these actions (La Quang & Le Khac 2020), although NGOs are, in part, carrying out some of them under existing projects (in particular, Action points 1, 3 and 4).

Box 2. Forest cover trends within gibbon habitats in Vietnam.

B2.1. Introduction

All gibbon species are forest-dependent and, whilst they appear to tolerate some degradation of forest quality (Fan *et al.* 2013; Cheyne *et al.* 2016; Nguyen Dinh *et al.* 2020), they cannot survive without tree cover of some sort. High forest cover is therefore a key basic requirement for the persistence of a gibbon population in a given site.

Vietnam's forest cover has undergone dramatic changes in recent decades, with a substantial increase in the area devoted to tree plantations and an apparent rebounding of forest cover to levels last seen in the 1940s (World Bank, 2019; based on official government data). Whilst forest cover dynamics in Vietnam have shown complex patterns over space and time (Cochard *et al.* 2017; Cochard *et al.* 2020), and have also been subject to differing definitions of what constitutes a forest (Cao Phan *et al.* 2021), it is nonetheless clear that intact, closed-canopy forests – the forest type most closely associated with gibbons – have continued to shrink in area year-on-year (Hansen *et al.* 2013; World Bank, 2019; Cochard *et al.* 2020; Cao Phan *et al.* 2021). Indeed, official government data estimates that a mere 5% of remaining natural forests in Vietnam are classified as "rich forest", i.e. forests in good condition (World Bank, 2019).

These national-level analyses are useful for understanding the broad trends in forest cover in Vietnam but, given the high spatial variability in trends across Vietnam, they offer limited insights into forest cover trends specifically where Vietnam's gibbons occur. Here, we fill this knowledge gap by analysing accurate land cover maps for Vietnam that have recently become available for the first time (Cao Phan *et al.* 2021). These maps cover the period 1990-2020 (in 5-year intervals) and, importantly, discriminate between natural forest and plantations.

B2.2. Methods

We processed land cover maps from Cao Phan *et al.* (2021) to extract trends in forest cover for each of the four light-cheeked gibbons (*N. leucogenys, N. siki, N. annamensis* and *N. gabriellae*). We did not include the cao vit gibbon (*N. nasutus*) and western black gibbon (*N. concolor*) in the analysis because forest cover within their extremely limited ranges in Vietnam has been relatively stable in recent decades. We focussed on natural forest and excluded plantations, by only including in our analysis the three natural forest categories in Cao Phan *et al.* (2021), i.e. deciduous broadleaf forest, evergreen broadleaf forest and evergreen needleleaf forest. We also excluded any forest regrowth in each 5-year time-step, by only allowing natural forest to be lost, not gained. We did this because: 1) secondary forest is likely of much lower forest quality for gibbons, perhaps taking decades before it is suitable habitat and, 2) pixels showing natural re-growth may be plantation forest, due to the difficulty of classifying forest types from satellite data (Cao Phan *et al.* 2021).

We calculated forest cover over time, as well as annual percentage change statistics, within both the extent of occurrence (EOO) and area of occupancy (AOO) of each of the four light-cheeked gibbon species. EOOs for each species were defined from minimum convex polygons around all sites identified for each species since 2000 (excluding marine areas and land outside Vietnam). AOOs were defined simply as the sites identified as still occupied in this review.

B2.3. Results

Results indicate that intact forest is continuing to decline at both the scale of gibbon EOOs (**Fig. B2.1**) and AOOs (**Fig. B2.2**), with rates of EOO and AOO forest loss in the range 0.49-1.3% and 0.36-0.48%, respectively, for the most recent period of 2015-2020. However, rates of forest loss have declined over time, with recent rates much lower than those seen in the 1990s and early 2000s.

Comparing across species, both absolute and percentage forest loss has been highest within the EOO and AOO of *N. gabriellae*. This species lost 16,785 km² of forest across its range between 1990 and 2020 (61% of the 1990 area), including 1,752 km² of forest within occupied sites over the same period (33% of the 1990 area). Forest loss has also been particularly high within the EOO of *N. leucogenys*, amounting to 14,325 km² (60% of the 1990 area). As of 2020, the forest cover within the range of each species was 19%, 50%, 40% and 22% for *N. leucogenys*, *N. siki*, *N. annamensis*, and *N. gabriellae*, respectively.

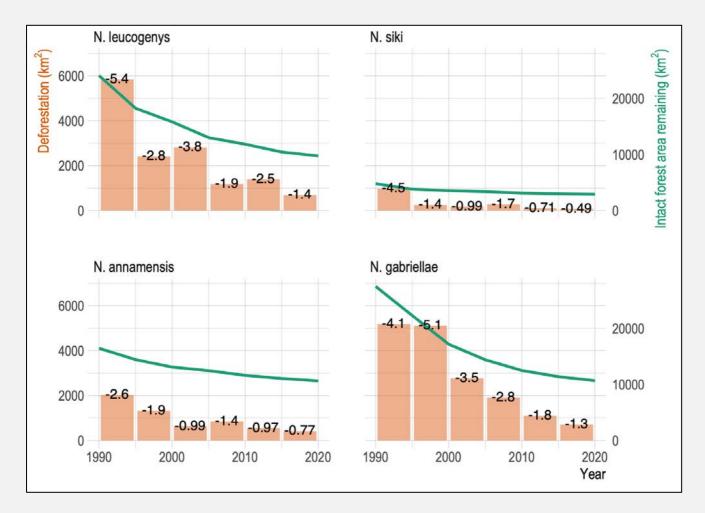


Figure B2.1. Remaining area of intact forest within the extent of occurrence of each of the four light-cheeked gibbon species in Vietnam (green line), as well as absolute area of deforestation in 5-year periods (orange bars). Values shown on each bar are the average annual percentage rates of deforestation for each 5-year period. Data were extracted from Cao Phan *et al.* (2021) and processed to exclude secondary forest.

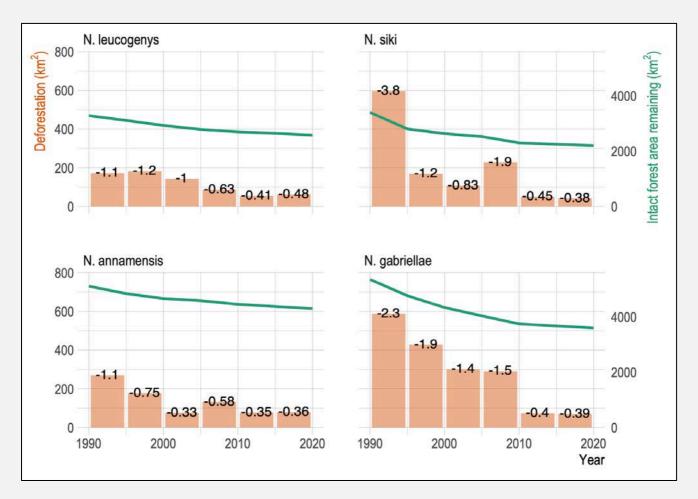


Figure B2.2. Remaining area of intact forest within the area of occupancy of each of the four light-cheeked gibbon species in Vietnam (green line), as well as absolute area of deforestation in 5-year periods (orange bars). Values shown on each bar are the average annual percentage rates of deforestation for each 5-year period. Data were extracted from Cao Phan *et al.* (2021) and processed to exclude secondary forest.

For *N. leucogenys* and *N. gabriellae*, intense and widespread deforestation has rendered many remaining occupied sites as islands within a matrix of non-habitat (**Fig. B2.3**). For example, Sop Cop NR in Son La Province and Nam Nung NR in Dak Nong Province (occupied sites for *N. leucogenys* and *N. gabriellae*, respectively) are both surrounded by deforested areas. For *N. siki*, deforestation has mainly been concentrated at the peripheries of the forest enterprises that host the species, including Bong Lai and Khe Giua SFEs. For *N. annamensis*, deforestation within the Central Highlands region (especially in Kon Tum and Quang Nam provinces) has been particularly high, which has substantially fragmented the remaining habitat.

B2.4. Conclusions

Overall, these analyses underline the fact that deforestation has had a major impact on Vietnam's four light-cheeked gibbons over the last three decades, in particular on *N. gabriellae* and *N. leucogenys*. This deforestation has been occurring both within occupied sites and across the broader landscapes surrounding occupied sites. Deforestation within occupied sites has likely had a direct effect on gibbon populations, by reducing the availability, connectivity and quality of habitat within a site, ultimately leading to population declines. In addition, reduced landscape forest cover has likely led to higher pressure being put on remaining forests, for example from logging, hunting and NTFP extraction. Reductions in landscape forest cover have

also reduced connectivity between forest blocks and further reduced the options for the future re-expansion and reintroduction of gibbon populations.

Despite these significant impacts of deforestation, there are signs that rates of forest loss have been declining over time. With greater investment in protected areas and better management of production forests, there is an opportunity to finally bring an end to the loss of intact forest and begin to restore and recover the habitats of Vietnam's gibbons.

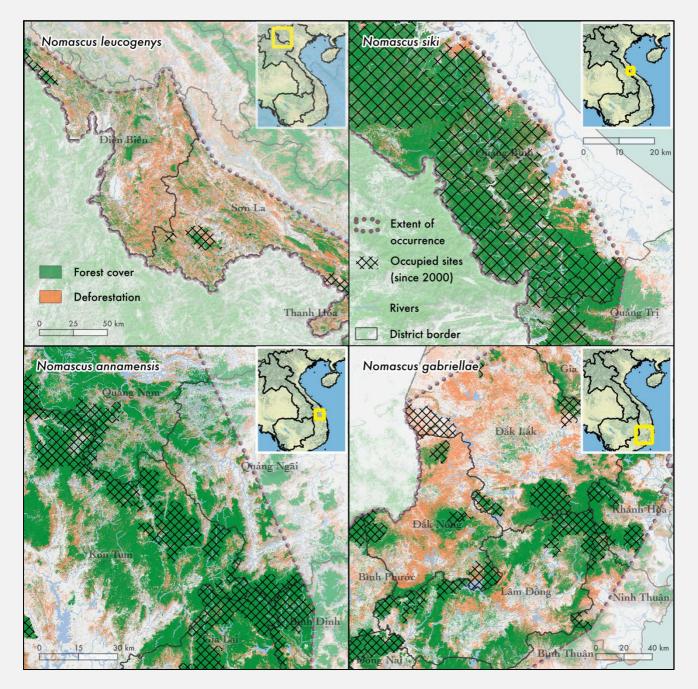


Figure B2.3. Patterns of deforestation over the period 1990-2020 for each of Vietnam's four light-cheeked gibbon species. Each panel focuses on the areas of most intensive deforestation for each species. Deforestation data (orange pixels) were extracted from Cao Phan *et al.* (2021), whilst forest cover for 2022 (green pixels) was extracted from the Global Forest Change Dataset (Hansen *et al.* 2013). All sites which are known to have held gibbons are indicated (hashed areas).

Southern white-cheeked



Image: © Association Anoulak (Nomascus siki/leucogenys)

Fast facts:

- Found over a small extent within Vietnam, primarily in Quang Binh Province and a small area of Ha Tinh and Quang Tri provinces
- Significant and well-connected habitat remains for the species along the border with Laos
- Recent surveys have improved our understanding of the species' status, with an estimated 500+ groups found along a corridor of forests from Phong Nha-Ke Bang NP (Quang Binh) down to Bac Huong Hoa NR (Quang Tri); no local extinctions have been documented in recent times
- Population densities, however, vary according to forest management status, with unprotected sites showing depressed populations, likely due to hunting and habitat degradation
- Priority is to bolster protection along the Quang Binh forest corridor and bring unprotected populations (e.g. in Quang Ninh PF and Khe Giua SFE) under better management

5. Southern white-cheeked gibbon (Nomascus siki)

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Summary

- Following revision of the taxonomy of *Nomascus* gibbons, the southern white-cheeked gibbon (*Nomascus siki*) was found to occur over a relatively narrow latitudinal extent in Vietnam and Laos, and hence it has the smallest distribution of the 'light-cheeked' gibbons
- The species primarily occurs in Quang Binh Province, with a small extent also in Ha Tinh (to the north) and Quang Tri (to the south), although there is still uncertainty about the range boundary between *N. siki* and *N. leucogenys*
- Within its relatively limited geographic range, there does at least remain significant areas of well-connected habitat; this forms a corridor extending for > 100 km along the border with Laos, from Phong Nha-Ke Bang NP down to Bac Huong Hoa NR
- Extensive surveys in recent years have uncovered >500 gibbon groups in this corridor, highlighting the substantial and irreplaceable value of these forests as one of the last *Nomascus* strongholds in the Indochina region (including contiguous forests in Laos); these surveys also suggest that hunting and habitat degradation have substantially reduced populations lying outside the protected area network (in watershed protection and production forests)
- Several important strongholds for the species exist in Vietnam, including: Phong Nha-Ke Bang NP; Quang Ninh PF; Khe Giua SFE; Dong Chau-Khe Nuoc Trong NR, and Bac Huong Hoa NR; no local extinctions of the species have been reported in recent times (since the first status review in 2000)
- Vast areas of limestone in Phong Nha-Ke Bang NP remain unsurveyed for the species, representing a knowledge gap for the species; the location of the range boundary with *N. leucogenys* (and whether there are areas of sympatry and-or hybridisation) also remains unclear
- A significant proportion of the known population of the species in Vietnam lies outside the protected area network (238 of 538 estimated groups, i.e. 44%), leaving them exposed to hunting and habitat degradation; given the already depressed populations in these areas, an urgent priority must be to improve the management and protection of these populations (especially in Quang Ninh PF and Khe Giua SFE)
- To date, relatively little dedicated conservation attention has been given to the southern white-cheeked gibbon, although it has likely benefited from broader conservation actions that have been implemented in protected areas within its range (such as in Phong Nha-Ke Bang NP)

5.1. Distribution

The southern white-cheeked gibbon is restricted to the central parts of Vietnam (**Fig. 6**). The distribution is almost wholly in Quang Binh Province, but also apparently extending into Quang Tri in Bac Huong Hoa NR (Nguyen Dinh *et al.* 2020). Taxonomic work to refine the range boundaries of Vietnam's gibbons before the last status review in 2011 led to a drastically reduced picture of its distribution (Van Ngoc *et al.* 2010d). The northern limit of the species is currently thought to be approximately the Gianh River (sometimes called the Rao Nay River), likely making populations in Tuyen Hoa (West) PF and Minh Hoa PF the most northern of those remaining. Questions remain about the populations in adjoining Ke Go NR and Khe Net proposed NR (i.e. the eastern section of Tuyen Hoa PF) and here we follow the previous status review (Rawson *et al.* 2011) in assigning these provisionally to the northern white-cheeked gibbon (*N. leucogenys*). The potential population in Huong Khe PF, as yet unsurveyed, is provisionally assigned here to *N. siki*, but acoustic and genetic data are needed to test this. Even with the exact geographic range unresolved, the southern white-cheeked gibbon is still clearly the most range-restricted of Vietnam's four 'light-cheeked' gibbon species (*N. leucogenys*, *N. siki*, *N. annamensis* and *N. gabriellae*).

Despite the southern white-cheeked gibbon's relatively narrow range, within this area populations of the species are perhaps faring comparatively better than other *Nomascus* species. Although at least some of the populations have been impacted by hunting and appear substantially below carrying capacity, no local extinctions have been documented since the first status review in 2000 (Geissmann *et al.* 2000; Rawson *et al.* 2011), assuming the extirpated population in Tuyen Hoa (East) PF was not *N. siki*. This relatively positive picture is attributed to the relatively high forest cover in Quang Binh Province (**Box 2**) and low human population densities in the mountains along the border with Laos (Tran Van *et al.* 2023).

Since the last status review, considerable work has been done to survey gibbon populations across *N. siki*'s range, giving us a much more complete picture of its status. In particular, the species exists in a long (>100 km) corridor of contiguous forests, spanning Phong Nha-Ke Bang in the north, down to Bac Huong Hoa NR in the south (Nguyen Dinh *et al.* 2020). Moreover, this corridor is bolstered on the Laos side with some large protected areas – including Hin Nam No NP (940 km²), Khoun Xe Nong Ma Provincial PA (680 km²) and Laving Lavern NPA (860 km²) – all with apparently large, albeit unquantified, gibbon populations (Rawson *et al.* 2011; Tran Van *et al.* 2023). This vast transboundary complex is one of the most critical landscapes for gibbon conservation in the entire Indochina region.

Outside Vietnam, the species only occurs in Laos, apparently between the Nam Theun-Nam Kading River in the north and the Bang Hiang River in the south (Van Ngoc *et al.* 2010d; Coudrat 2023). Key protected areas for the species include Phou Hin Poun NPA, Hin Nam No NPA, Khoun Xe Nong Ma Provincial PA, Laving Lavern NPA and Phou Xang He NPA. It may also extend as far south as Dong Phou Vieng NPA (Van Ngoc *et al.* 2010c; MAF 2011; Rawson *et al.* 2011). The apparently very large gibbon population in Nakai-Nam Theun NPA (Nanthavong 2013) is currently being investigated both in terms of its acoustic and genetic characteristics (Coudrat 2023). Preliminary acoustic results suggest that both *N. leucogenys* and *N. siki* occur in the park, with the former primarily occurring north of the Nam Theun-Nam Kading river and the latter south of the river (Coudrat 2023). The headwaters of the Nam Theun river may be only a partial barrier for gibbons, allowing for some exchange of individuals between the populations on either side of the river.

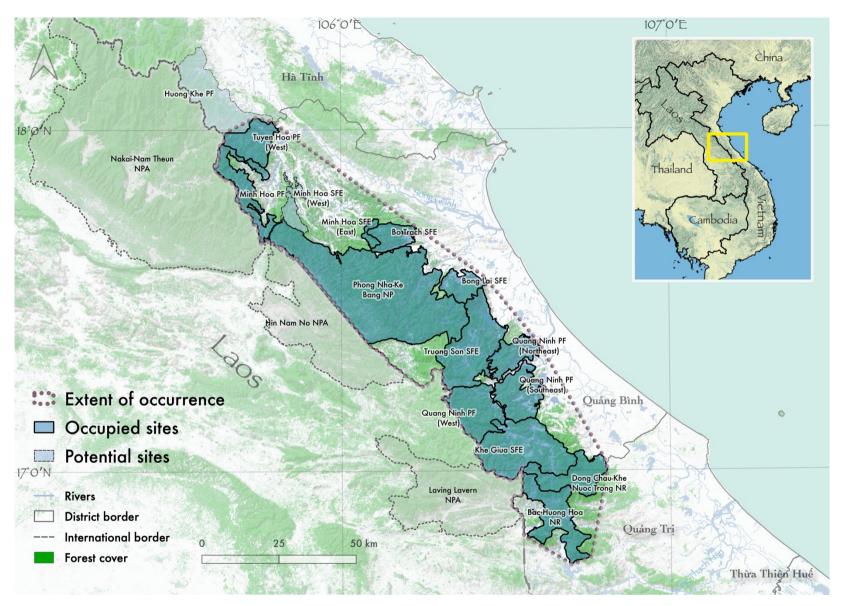


Figure 6. Extent of occurrence of the southern white-cheeked gibbon (*Nomascus siki*) in Vietnam, with all known and potential sites indicated. Forest cover data for 2022 are from the Global Forest Change dataset (Hansen *et al.* 2013). Key sites in Laos that connect with those in Vietnam are also shown.

 Table 5. Southern white-cheeked gibbon (Nomascus siki) sites in Vietnam since 2000.

Site	Province	Area (ha)	Survey year	Recorded # groups	Estimated # groups	Group density, per km²	Survey methods	Change since last assessment	Source
Ke Go NRª	Ha Tinh	21,759	2010	Extirpated?	-	-	Listening post survey	Now considered provisionally extirpated (4 groups reported in 2010)	Van Ngoc et al. 2010a; Nguyen Dinh D., pers. comm., 2023
Tuyen Hoa (East) PF (Khe Net proposed NR)ª	Quang Binh	23,534	2020	Extirpated	-	-	Listening post survey	Confirmed again as extirpated (last surveyed in 2010)	Le Trong <i>et al.</i> 2021
Huong Khe PF⁵	Ha Tinh	31,000	-	?	-	-	-	Newly-added as a potential gibbon site; contiguous with Vu Quang NP	
Tuyen Hoa (West) PF (part of Khe Ve proposed NR) ^b	Quang Binh	15,300	2021	2	-	-	Listening post survey	Previously referred to as Khe Ve proposed NR; 7 groups were reported in 2004 and 3 groups in 2008	Le Trong <i>et al.</i> 2021; Van Ngoc <i>et al.</i> 2011
Minh Hoa PF (overlaps with Giang Man proposed NR) ^b	Quang Binh	19,100	2020	6	-	-	Listening post survey	5 groups were recorded for Giang Man proposed NR in 2004	Le Trong <i>et al.</i> 2021
Minh Hoa (West) SFE	Quang Binh	6,900	-	?	-	-		Newly-added as a potential site for the species	
Bo Trach & Minh Hoa (East) SFEs (and Thuong Hoa commune)	Quang Binh	12,600	2021	3	-	-	Listening post survey	Newly-added as a confirmed area for the species	Le Trong <i>et al.</i> 2021
Phong Nha-Ke Bang NP	Quang Binh	123,300	2021	72	80	0.78 ^{cd}	Listening post survey and use of 'correction factors' ^e	Recorded # groups increased from 50 (survey in 2009)	Le Trong <i>et al.</i> 2021
Bong Lai SFE	Quang Binh	10,200	2020	2	-	-	Listening post survey	Newly-added as a confirmed area for the species; has not been the focus of a dedicated survey (2 groups were recorded	Le Trong <i>et al.</i> 2021; Nguyen Dinh D., pers. comm. 2023

								during surveys of neighbouring U Bo mountain)	
Truong Son SFE	Quang Binh	37,600	2019	14	24	0.29 ^d	Listening post survey and use of 'correction factors' ^e	Recorded # groups increased from 10 (survey in 2009)	Nguyen Dinh <i>et al.</i> 2020
Quang Ninh PF (West) (previously Long Dai PF)	Quang Binh	23,000	2019	52	82	0.94 ^d	Listening post survey and use of 'correction factors' ^e	Newly-added as a confirmed area for the species	Nguyen Dinh <i>et al.</i> 2020
Quang Ninh PF (Northeast) (previously part of Ba Ren PF)	Quang Binh	12,551	2023	19	-	-	Listening post survey	Newly-added as a confirmed area for the species	Nguyen Dinh D., pers. comm. 2023
Quang Ninh PF (Southeast) (previously part of Ba Ren PF)	Quang Binh	18,770	2023	1	-	-	Listening post survey	Newly-added as a confirmed area for the species	Nguyen Dinh D., pers. comm. 2023
Khe Giua SFE	Quang Binh	42,200	2019	38	99	0.57 ^d	Listening post survey and use of 'correction factors' ^e	Recorded # groups increased from 4 (survey in 2004)	Nguyen Dinh <i>et al.</i> 2020
Dong Chau-Khe Nuoc Trong NR	Quang Binh	22,132	2016	103	146	1.40 ^f	Listening post survey and use of 'correction factors' ^e	New NR (established in 2020) and now managed separately from Khe Giua SFE	Dang Ngoc <i>et al.</i> 2017
Bac Huong Hoa NR ^g	Quang Tri	25,300	2019	45	74	1.15 ^d	Listening post survey and use of 'correction factors' ^e	Recorded # groups increased from 23 (survey in 2009)	Nguyen Dinh <i>et al.</i> 2020
		Total gi (all time p		357	538				
	Total gro recent (post 2	only	357	538					

^aSites (in grey text) which are here assumed to harbour *N. leucogenys*, not *N. siki*, but warrant confirmation from further acoustic and genetic data. These sites are not included in the totals. ^bThe populations in these sites are likely to be *N. siki*, but this requires genetic investigation as it is an area of possible sympatry with *N. leucogenys*.

"This density estimate applies only to a non-limestone section of the park and is likely not representative of the whole area, which contains considerable areas of limestone.

^dDensity calculated on the basis of 1.5 km listening radius, and accounting for gibbons that may be missed if they did not sing.

*Correction factors were used to account for the fact that some gibbons may be missed in short surveys and that some areas of suitable habitat were unsurveyed.

^fDensity estimated on the basis of a reported sampling area of 104 km2, although it is unclear how this was estimated.

^gBac Huong Hoa NR has variously been reported as harbouring *N. annamensis* (Nguyen Van et al. 2017), *N. siki* (Nguyen Dinh et al. 2020) or both (Hoang Minh et al. 2023). We here assume it is *N. siki* given its location north of the assumed range boundary (Thach Han river) but further confirmation from acoustic and genetic data is needed.

5.2. Population status

The stronghold for the species is undoubtedly the corridor of forests running along the Laos border through Quang Binh Province and into northern Quang Tri. These forests have been surveyed extensively in recent years (Nguyen Dinh *et al.* 2020), revealing a substantial population of 500+ groups (**Table 5**). The largest populations appear to be in:

- iv) Phong Nha-Ke Bang NP
- v) Quang Ninh PF (western section)
- vi) Khe Giua SFE
- vii) Dong Chau-Khe Nuoc Trong NR
- viii) Bac Huong Hoa NR

Notably, a substantial proportion of the population in this corridor (238 of 538 estimated groups, i.e. 44%) lies outside protected areas, in a mixture of watershed protection forests and production forests.

It is worth noting that population sizes along this corridor were estimated using a 'correction factor' approach (Jiang *et al.* 2006; Vu Tien & Dong Thanh 2015), which may lead to bias in the estimates of population size. This is due to the use of an arbitrary listening radius (often 1.5 or 2 km is used), as well as biases in the daily calling probability parameter that is critical to the method (Kidney *et al.* 2016). In this way, the method can be considered a preliminary approach to estimating the total number of groups in an area. Further work is needed to validate the estimates, ideally using the latest statistical advances (distance sampling or spatially explicit capture-recapture), combined with acoustic recordings.

To the north of this main corridor of forests, there appear to be remnant gibbon populations in Minh Hoa SFE, Minh Hoa PF and Tuyen Hoa PF (Le Trong *et al.* 2021). Systematic surveys of these populations, covering all potential areas, remain to be done however. Further north, Huong Khe PF remains unsurveyed but appears to contain tracts of intact habitat. The taxonomic status of some of these populations remains in doubt, particularly those in the Minh Hoa, Tuyen Hoa and Huong Khe PFs. We follow previous work in considering them likely to be southern white-cheeked gibbons (Van Ngoc *et al.* 2010d; Rawson *et al.* 2011), but further work is required to rule out the possibility that they are in fact northern white-cheeked gibbons and-or hybrids between the two species.

5.3. Population trends

Trends in southern white-cheeked gibbon populations remain unknown, with extensive surveys only recently having been completed. Certainly, the species has been subject to intense pressures from habitat loss and degradation, as well as hunting, in recent decades (Rawson *et al.* 2011). This is reflected in the apparently low-density populations, especially in production forests where populations have been exposed to the highest pressures from hunting, logging and forest clearance. It may be the case, though, that *N. siki* populations in some areas may have begun to gradually recover in recent years with the reduced dependence on forests for local livelihoods in many parts of rural Vietnam. Over the coming decade, it may be possible to detect if any recoveries are occurring, by comparing the recent baseline surveys against new data (assuming similar survey locations are used).

5.4. Estimated population densities

Southern white-cheeked gibbon densities appear to be relatively high in some sites in Vietnam (**Table 5**), although there is considerable variation depending on the type of forest management. The highest densities appear to be in the adjacent Dong Chau-Khe Nuoc Trong (only gazetted in 2020) and Bac-Huong Hoa NRs. Together, these two nature reserves cover >400 km² and, with estimated group densities exceeding 1 per km² (Nguyen Dinh *et al.* 2020), represent perhaps the best hope in Vietnam for conserving N. siki long into the future. Further north in the corridor of forests running through Quang Binh, densities in the two production forests – Khe Giua and Truong Son SFEs – are lower (0.57 and 0.29 groups per km², respectively) and more indicative of populations that have been subject to pressures from hunting and habitat degradation (Nguyen Dinh et al. 2020). The western section of Quang Ninh PF (previously Long Dai PF), despite not being managed explicitly for its biodiversity values and existing outside of Vietnam's formal protected area network, was estimated to have gibbon group densities approaching those in the nature reserves further south (Nguyen Dinh et al. 2020). The southeast section of Quang Ninh PF is primarily limestone habitat, albeit with some valley areas, and is unlikely to be optimal habitat for the species (Nguyen Dinh. D., pers. obs., 2023).

The gibbons in Phong Nha-Ke Bang have been surveyed multiple times in various areas and with different methods (Ruppell 2007; Haus et al. 2009; Le Trong et al. 2009, 2021; Bleisch et al. 2012). The methods used mostly preclude density estimation (due to a lack of systematic placement of listening posts or survey routes, or because only a limited area was surveyed), though very approximate estimates can be obtained by making crude assumptions about the surveyed areas. For example, an estimate of 0.7 groups per km² can be recovered from Ruppell (2007) and 0.53 groups per km² from Le Trong et al. (2009). More recently, the same 'correction factor' approach that was used in the corridor of forests to the south was used (Le Trong et al. 2021), allowing for more direct comparison with other N. siki sites. In this case, densities were estimated at 0.78 groups per km², which compares favourably with densities estimated elsewhere. Note, however, that all of these estimates for the park refer to localised areas, principally U Bo mountain, that are not representative of the overall park. Most of Phong Nha-Ke Bang's vast area is composed of rugged limestone habitat, with pinnacles, caves, sinkholes and steep cliffs. Gibbons are generally thought to occur at very low density in these areas, with only sporadic records during biodiversity work (Bui Van T., pers. comm., 2023). However, due the inaccessibility of these areas, especially in the remote interior of the park towards the Laos border, systematic survey data are lacking.

To our knowledge, densities in Laos remain largely unknown, making it challenging to draw meaningful comparisons with those in Vietnam. In Nam Kading NPA, Hallam *et al.* (2016) estimated densities of *Nomascus* gibbons (densities did not vary between the putative *N. leucogenys* and *N. siki* groups) to be 0.21 groups per km². Density was estimated in this study using repeat presence-absence surveys along line transects, an approach that would be expected to underestimate density, due to unmodelled heterogeneity in the probability of detecting gibbons according to how far away they are (Kidney *et al.* 2016). Nonetheless, densities in Nam Kading appear to be below carrying capacity and perhaps lower than those in some sites in Vietnam. In Nakai-Nam Theun NPA, the population density in a 120 km² section of the park was estimated to be high, at 2.7 groups per km² (Nanthavong 2013). However, preliminary investigation of the acoustics of the gibbons in Nakai-Nam Theun NPA suggest that the surveyed area, which was north of the Nam Theun river, would most likely correspond to *N. leucogenys*, not *N. siki* (Coudrat 2023).

5.5. Recent research findings

Beyond population surveys, the southern white-cheeked gibbon has not yet been studied intensively in the field in Vietnam, owing to the practical difficulty of making direct observations of the species in the wild. Consequently, we have limited information about the species' demographic rates, life history and behaviour, beyond what we can infer from related gibbon species. Some aspects of its ecology can at least be inferred from population surveys done to date (e.g. Nguyen Dinh *et al.* 2020; Le Trong *et al.* 2021). For example, densities appear to vary depending on the type of forest management, with populations faring considerably better in intact, well-protected forests within Vietnam's protected area network, which presumably have lower hunting pressures and more food resources for gibbons. By contrast, populations appear depressed in production forests and protection forests managed for their watershed function, likely because of the higher hunting pressures and more degraded state of the habitat. Further studies may help to disentangle the effects of hunting and timber logging.

A recent study which modelled the distribution of the species showed an apparently strong relationship between the species' presence and climatic variables, in particular precipitation patterns (Tran Van *et al.* 2023). Areas with more constant rain throughout the year were more likely to be suitable habitat (Tran Van *et al.* 2023). In this study, metrics of habitat quality, such as forest cover and canopy height, were found to be less important than climatic variables, but this may have been due to the relatively coarse resolution of the model (approximately 1 km pixels). No hunting variables were included in the models, owing to the difficult of measuring hunting pressure at large scales.

5.6. Knowledge gaps

With recent surveys, the status of the southern white-cheeked gibbon is much better known than it was in the last review in 2011. Even so, knowledge gaps remain. In those sites that have been surveyed, survey coverage has not always been consistent, making it difficult to extrapolate results over a larger area. This is the case, for example, in Truong Son SFE and Bac Huong Hoa NR. It also applies to Phong Nha-Ke Bang NP, where surveys have almost entirely focussed on U Bo mountain, which is not karst and is unrepresentative of the rest of the park. The suitability of limestone habitat for the species is likely low, but remains unquantified. As a result, there is no park-wide estimate of the population in Phong Nha-Ke Bang. Populations north of Phong Nha-Ke Bang NP – particularly in Minh Hoa, Tuyen Hoa and Huong Khe PFs – remain of uncertain taxonomic status. Further acoustic and genetic work in this zone of potential overlap with *N. leucogenys* is needed.

In Laos, the taxonomic status of the gibbons in Nakai-Nam Theun NPA currently remains uncertain, although work is already underway to investigate the acoustic and genetic characteristics of the population (Coudrat 2023). The uncertainty surrounding this apparently very large population in turn introduces uncertainty into conservation planning for *Nomascus* gibbons at the regional level. Preliminary acoustic results suggest that both white-cheeked gibbon species occur in the park, with the Nam Theun-Nam Kading river representing at least a partial dispersal barrier between the northern and southern species (Coudrat 2023).

5.7. Emerging threats

Recent surveys for the species have revealed that a relatively large proportion (44%) of the remaining groups currently lie outside the protected area network, totalling an estimated 238 groups (**Table 5**). Population densities in these areas are evidently lower than in the nature reserves, likely because of higher pressures from hunting and habitat degradation (Nguyen Dinh *et al.* 2020). Targeted management of these gibbon populations is urgently needed if further population extinctions of *Nomascus* gibbons are to be avoided in Vietnam. This might be achieved through, for example, gazettement of key areas as nature reserves (if appropriate and assuming Free, Prior and Informed Consent from local communities) and-or specific interventions to reduce hunting- and logging-related crime.

5.8. Conservation management

5.8.1. In-situ conservation

The southern white-cheeked gibbon has not been the focus of any field conservation efforts to our knowledge. Efforts on the species to date, led by VietNature, have focussed on assessing the status of the species across its relatively narrow range in Quang Binh and Quang Tri provinces (Nguyen Dinh *et al.* 2020; Le Trong *et al.* 2021). However, with the evidence-base for conservation of the species now vastly improved, VietNature plans to shift focus towards conservation actions, including building the capacity for protected area managers and other forest owners to more effectively conserve their gibbon populations (Le Trong T., pers. comm., 2023).

5.8.2. Ex-situ conservation

The Endangered Primate Rescue Center in Cuc Phuong NP houses eight *N. siki* individuals (four males and four females) rescued from the illegal wildlife trade, of which seven are of breeding age. Currently, the EPRC has one breeding pair (with two offspring), with the other three females on birth control (E. Schwierz, pers. comm., 2023). No releases are planned for this species, with the management plan for EPRC focussing instead on potential future releases of *N. leucogenys*.

5.8.3. Policy

The southern white-cheeked gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. It was listed as Endangered in Vietnam's national Red Data Book (VAST 2007).

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) carry out comprehensive population surveys in key sites and set up long-term monitoring; 2) control the possession and use of firearms in communities adjacent to key populations of the species; 3) protect the highest density areas for the species with targeted and sustained patrol efforts, and 4) carry out detailed threat assessments and produce plans to mitigate those threats. As for the other gibbon species, we are not aware of any specific activities or budget thus far to achieve these actions (La Quang & Le Khac 2020). NGOs and academic institutions have, however, made significant progress towards thoroughly surveying the species (Action point 1).

Northern yellow-cheeked **gibbon** (Nomascus annamensis)

Image: © Endangered Primate Rescue Centre

Fast facts:

- Described as a species only in 2010, having long been overlooked
- Since then, important information about its geographic range and status in south-central Vietnam has emerged

and the second

- Key identified populations are in: Dak Rong and Phong Dien NRs (60+ groups); the Saola NRs and connecting forests (60 groups); Song Thanh NP (400+ groups estimated); Kon Plong District (400+ groups estimated), Kon Ka Kinh NP and connecting forests (170+ groups estimated), and Chu Mom Ray NP (39 groups)
- Threats from habitat loss and degradation, as well as hunting, appear to be intense (especially in the Central Highlands provinces of Kon Tum and Gia Lai)
- Priority is to address the twin pressures from large-scale development and hunting, by bringing attention to critical populations and, in concert with local communities, reducing hunting crimes

6. Northern yellow-cheeked gibbon (Nomascus annamensis)

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Summary

- The northern yellow-cheeked gibbon (*Nomascus annamensis*) was only formally recognised as a distinct species in 2010, but since then information about its status has improved at a fast rate
- The species occurs over a relatively large extent across eight provinces and one municipality, stretching from Quang Tri down to Binh Dinh; however, uncertainty remains about the northern limit of its range (the species boundary with *N. siki*)
- Remnant populations within its large range are highly fragmented and depressed, with pressures ongoing from deforestation, habitat degradation and hunting
- Six key areas for the species appear to remain: i) the contiguous Dak Rong and Phong Dien NRs; ii) a stretch of contiguous protected areas along the Thua Thien Hue – Quang Nam border (including the Saola NRs and Bach Ma NP) running to the Laos border; iii) Song Thanh NP; iv) Kon Plong District; v) Kon Ka Kinh NP and connecting forests in Binh Dinh, Quang Ngai and Kon Tum, and vi) Chu Mom Ray NP, connecting with Virachey NP in Cambodia
- It remains a poorly-studied species in Vietnam (and indeed globally), with basic information about its life-history largely unknown
- Of the four light-cheeked gibbon species, *N. annamensis* appears to be under the greatest current pressure and likely suffering the fastest population declines, with threats in the Central Highlands, in particular, likely to intensify over coming years due to large-scale development projects
- Relatively little conservation effort has been focussed directly on the species, but it
 has nonetheless likely benefitted from primate conservation projects in Kon Plong
 District and Kon Ka Kinh NP, as well as substantial investments in conservation in
 Thua Thien Hue and Quang Nam provinces over the last decade and more

6.1. Distribution

Until relatively recently, the northern yellow-cheeked gibbon remained a cryptic species, subsumed under *Nomascus gabriellae*. On the basis of its distinct combination of morphology (resembling *N. gabriellae*), vocalisations (resembling *N. siki*) and genetics (most closely related to *N. gabriellae*), it was formally described in 2010 (Van Ngoc *et al.* 2010c), just in time to be included in the last gibbon status review. Much of what we know about the distribution of the species still comes from this foundational work.

The species spans eight provinces (as well as Da Nang municipality) in south-central Vietnam, from Quang Tri in the north, to Binh Dinh in the south (**Fig. 7**). The northern limit of its range in Vietnam was suggested to be the Thach Han River (Rawson *et al.* 2011), although inspection of acoustic data has since led to suggestions that the species occurs in Bac Huong Hoa NR (Nguyen Van *et al.* 2017), just north of the Thach Han River. Others have concluded

from their own acoustic data that the gibbons in Bac Huong Hoa NR were *N. siki* (Nguyen Dinh D., pers. comm., 2023). It may be the case that the reserve holds both species (Hoang Minh *et al.* 2023). We here follow previous work in assigning populations in Bac Huong Hoa to *N. siki*, pending further acoustic and genetic investigation (and to avoid double-counting of *Nomascus* populations). Uncertainty is also associated with the southern yellow-cheeked gibbon's southern range boundary. The Ba River was suggested to be the southern boundary for the species (Rawson *et al.* 2011), although *N. gabriellae* has since been reported from A Yun Pa NR (Tran Van & Hoang Minh 2015), north of the Ba River. The boundary between *N. annamensis* and *N. gabriellae* might in fact be climatic, with recent species distribution modelling indicating that the former species prefers more seasonal forests than its congener, i.e. those that vary in their annual temperature by more than 2°C (Hoang Minh *et al.* 2023).

Across the northern yellow-cheeked gibbon's broad range in south-central Vietnam, rates of deforestation and infrastructure development have been high in recent decades, resulting in a fragmented distribution (**Fig. 7**; **Box 2**). Today, six key areas for the species appear to remain:

- i) the contiguous Dak Rong and Phong Dien NRs
- ii) protected forests along the Thua Thien Hue Quang Nam border (including the Saola NRs and Bach Map NP), contiguous with Xe Sap NPA in Laos
- iii) Song Thanh NP
- iv) Kon Plong District, in particular the population on Ngoc Boc mountain
- v) the intersection of Kon Tum, Gia Lai, Binh Dinh and Quang Ngai (including Kon Ka Kinh NP, Kon Cha Rang NR, An Toan NR and Ba To proposed NR)
- vi) Chu Mom Ray NP, contiguous with Virachey NP in Cambodia

Outside these areas, population information is mostly sparse, with many forest areas outside protected areas lacking robust and recent data. This makes it difficult to ascertain if any populations have been extirpated since the last status review. Recent surveys in Vinh Thanh District, Binh Dinh Province, suggest that this site, likely to have been inhabited by gibbons in the past, no longer has a functional population and may have been extirpated (Hoang Minh *et al.* 2023).

Outside Vietnam, the species also occurs in southern Laos and northeast Cambodia. In Laos, *N. annamensis* has been reported from a large number of forest areas, some of which contain significant areas of intact habitat (MAF 2011). However, the current status of the species is highly uncertain, with much of the available data now more than a decade old (MAF 2011). Populations were reportedly in decline in 2008 (Duckworth 2008) and it is unclear whether these declines have continued, resulting in any population extirpations. The best hopes for the species in Laos appear to lie in Xe Sap NPA, Xe Pian NPA and Dong Ampham NPA (MAF 2011; Hoang Van *et al.* 2018).

In Cambodia, the species is known from two large and adjoining PAs in the furthest northeast corner of the country: Veun Sai-Siem Pang NP and Virachey NP. Both PAs apparently have very large gibbon populations – approximately 500 and 2,000 groups, respectively (Rawson *et al.* 2012; Sinovas P., pers. comm., 2020) – and hunting, although continuing, appears to be declining and is constrained by the limited availability of firearms in the region (Murray & Sinovas 2019; McGrath & Behie 2021).

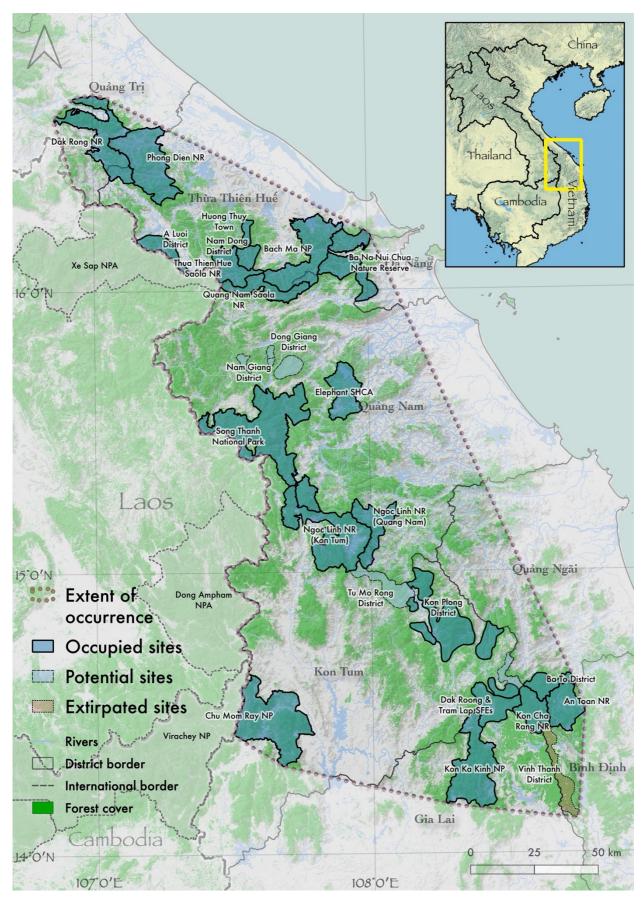


Figure 7. Extent of occurrence of the northern yellow-cheeked gibbon (*Nomascus annamensis*) in Vietnam, with all known, potential and extirpated sites indicated. Occupied areas of Kon Plong District are shown as six distinct areas, reflecting the fragmentation of this population. Forest cover for 2022 is from 'Global Forest Change' (Hansen *et al.* 2013). Sites in Cambodia and Laos that are mentioned in the text are also shown.

6.2. Population status

The recognition of *N. annamensis* as a distinct species has led to renewed interest in gibbon conservation in the Central Highlands, resulting in several new population surveys since the last status review (**Table 6**). The largest populations uncovered from these surveys to date are in Song Thanh NP and Kon Plong District (Tran Van & Vu Tien 2020; Wearn *et al.* 2021c).

In Song Thanh NP, 36 groups were directly recorded and more than 400 were estimated to be present over the whole park based on a distance sampling approach and modelling of suitable habitat (Tran Van & Vu Tien 2020). The very large number of groups predicted to live in Song Thanh NP is a result both of its considerable size (766 km²) and the presence of expansive areas of intact habitat (except in the north-eastern section of the park).

In Kon Plong District, 46 groups were directly recorded during a survey in 2020, with more than 480 potentially occurring over the whole district, based on spatially explicit capture-recapture modelling of the data and accounting for available habitat (Wearn *et al.* 2021c). By combining the 2020 survey data with previous data collected over 2016 and 2017, 90 groups were directly confirmed in total. The relatively large number of groups in Kon Plong District is in part due to its very large size (2,248 km²) and high forest cover (>80%), as well as the large population (140 groups) that has survived on the remote and mostly unlogged Ngoc Boc mountain in the centre of the district (Wearn *et al.* 2021c). Gibbon densities in the southern portion of Kon Plong District are considerably lower, due in part to more extensive development and road-building, but perhaps also cultural factors (in particular, variation in gun hunting practices among different villages and ethnic groups). This southern area of Kon Plong represents a key break in a 150 km chain of contiguous forests stretching from Song Thanh NP all the way down to Kon Ka Kinh NP.

In the contiguous Dak Rong and Phong Dien NRs, the gibbon population is yet to surveyed using systematic and robust methods that allow extrapolation to the whole 790 km² area. But, as many as 82 groups were counted during surveys done more than a decade ago (Nguyen Quang et al. 2010; Rawson et al. 2011; Table 6), resulting in it being identified as the top priority for the species in the last status review. Although a considerable area of habitat remains over the two reserves, it appears that hunting (and perhaps habitat disturbance) has eroded the population in recent years. Surveys in Dak Rong NR using passive acoustic recorders found that just 30% of recording sites were estimated to be occupied by gibbons in 2022, compared to 58% in 2019 (Vu Tien et al. 2023); areas in the north of the reserve apparently lacked gibbons altogether (Vu Tien & Doherty 2021). The reserve management estimates that it has 37 of the original 56 groups remaining (Dak Rong Nature Reserve 2021). It is unclear if the gibbons in Phong Dien NR have suffered a similar fate. A population survey of the whole forest block, ideally using standardised and robust methods (e.g. distance sampling or spatially explicit capture-recapture), would allow for a clearer assessment of the state of the population as a whole and how it compares with other northern yellow-cheeked gibbon sites.

The complex of parks, reserves and proposed PAs situated on the confluence of Kon Tum, Gia Lai, Quang Ngai and Binh Dinh provinces is likely to be another key area for the northern yellow-cheeked gibbon. This complex includes a national park at its core (Kon Ka Kinh NP), alongside two nature reserves (Kon Cha Rang and An Toan NRs), a proposed NR (Ba To) and two SFEs (Dak Roong and Tram Lap). Combining data from surveys in the period 2008-2016, an estimated 186 groups occur in this area (**Table 6**), and likely more exist in

unsurveyed areas (for example, populations on the Kon Tum side – in Hieu Commune, Kon Plong District – remain unsurveyed). This is an area where gun hunting has been especially prevalent, at least in the past (Ha Thang 2007; Luu Quang *et al.* 2010). If populations here are allowed to recover, it could be a key landscape for the future of the species given its large area (1,145 km² of proposed and established PAs).

The only 'ridge to reef' landscape in Vietnam - running from the Laos border to the ocean is home to northern yellow-cheeked gibbons. This landscape is composed of a complex of reserves along the Thua Thien Hue – Quang Nam – Da Nang border area, including the two Saola NRs, Bach Ma NP and Ba Na-Nui Chua NR. Although bisected by roads (including some built in recent years, including through Bach Ma NP) and major developments (e.g. in Ba Na-Nui Chua NR), this large landscape contains considerable areas of intact and contiguous forest and includes 937 km² of established PAs. It is also contiguous with Xe Sap NPA, a national conservation priority for the northern yellow-cheeked gibbon in Laos (MAF 2011). Despite considerable conservation attention on the landscape, robust and large-scale gibbon population surveys have not been done to date, with available data (mostly more than a decade old) confirming 60 gibbon groups (Table 6). Although population data are lacking, acoustic monitoring in the Saola NRs and Bach Ma NP showed that approximately 75% of survey sites were occupied by gibbons and that the species' distribution was stable between 2012 and 2016 (Vu Tien et al. 2020). With scant occupancy data available from elsewhere for comparison (except for Dak Rong NR), it is difficult to place this in context, but the population appears to be relatively healthy and might have a strong basis for future recovery. Parts of this landscape have not previously been considered a high priority for northern yellow-cheeked gibbon in Vietnam (e.g. Rawson et al. 2011) and so systematic population surveys in the core areas of this landscape might help to re-evaluate this.

Chu Mom Ray NP has not previously been highlighted as a key site for the northern yellowcheeked gibbon, but surveys in 2019 using passive acoustic recorders have suggested that it could harbour among the largest populations in Vietnam (Vu Tien, T., unpublished data). Across 62 recording sites, 39 registered gibbons (63%). Given that recorders were independent (3 km apart), this suggests a minimum of 39 gibbon groups in the park, and likely many more. Gibbons were also detected at the southern border of the park, where it adjoins forestry enterprise areas; these SFEs reportedly also harbour gibbons. Chu Mom Ray NP is also of importance for its connectivity with Virachey NP across the border in Cambodia. Together, Chu Mom Ray and Virachey NPs host the largest contiguous population of northern yellow-cheeked gibbons in existence.

6.3. Population trends

Only scant quantitative data are available to assess population trends of the northern yellowcheeked gibbon, whether in Vietnam or in Laos and Cambodia. In the last status review, population trends across *N. annamensis* sites were mostly assessed as 'unknown', but in Song Thanh NP, Kon Ka Kinh NP and Kon Cha Rang NR sufficient information was deemed to be available to assess populations as declining.
 Table 6. Northern yellow-cheeked gibbon (Nomascus annamensis) sites in Vietnam since 2000.

Site	Province	Area (ha)	Survey year	Recorded # groups	Estimated # groups	Group density, per km ²	Survey methods	Change since last assessment	Source
Bac Huong Hoa NR ^a	Quang Tri	25,300	2019	45	74	1.15 ^b	Listening post survey and use of 'correction factors' ^c	Recorded # groups increased from 23 (survey in 2009)	Nguyen Dinh <i>et</i> <i>al.</i> 2020
Dak Rong NR	Quang Tri	37,640	2021	9	37	-	Recce and listening post surveys	Recorded # groups decreased from 56 (survey in 2010)	Dak Rong Nature Reserve 2021
Phong Dien NR	Thua Thien Hue	41,494	2010	26	-	-	Recce and listening post surveys		Nguyen Quanh <i>et al.</i> 2010
A Luoi District (including A Luoi PF) ^d	Thua Thien Hue	10,500	2009	8	-	-	Listening post survey		Nguyen Quanh <i>et al.</i> 2010
Huong Thuy town	Thua Thien Hue	3,150	2009	2	-	-	Listening post survey	Newly-added as a confirmed area for the species	Nguyen Quanh <i>et al.</i> 2010
Nam Dong District (including Nam Dong PF) ^d	Thua Thien Hue	6,200	2009	4	-	-	Listening post survey		Nguyen Quanh <i>et al.</i> 2010
Thua Thien Hue Saola NR	Thua Thien Hue	15,490	2010	14	-	-	Listening post survey		Nguyen Quanh <i>et al.</i> 2010
Quang Nam Saola NR	Quang Nam	15,980	2012	13	-	-	Listening post survey	First (albeit small-scale) survey of the gibbon population in this site	Nguyen Van, Van Ngoc & Le Vu 2013
Bach Ma NP	Thua Thien Hue	37,487	2009	13	-	-	Listening post survey	Recorded # groups increased from 8 (survey in 2001)	Nguyen Van <i>et</i> <i>al.</i> 2017
Ba Na-Nui Chua NR	Da Nang	32,377	2017	14	-	-	Listening post survey	First (albeit small-scale) survey of the gibbon population in this site	Bui Van <i>et al.</i> 2019

Dong Giang and Tay Giang Districts	Quang Nam	5,000	2005	Extirpated?	-	-	Listening post survey	Unprotected forests in these districts recognised as distinct from Quang Nam Saola NR; in 2005, 30 groups were reported and threats were high	Rawson <i>et al.</i> 2011
Nam Giang District	Quang Nam	10,000	2005	Extirpated?	-	-	Interviews	Unprotected forests in Nam Giang District recognised as distinct from Song Thanh NP	Rawson <i>et al.</i> 2011
Song Thanh NP	Quang Nam	76,593	2019	36	443 (95% CI: 278- 707)	0.58 (95% CI: 0.36- 0.92) ^e	Distance sampling from listening posts	Recorded # groups increased from 17 (survey in 2004)	Tran Van & Vu Tien, 2020
Elephant Species & Habitat Conservation Area ('Hon Mo forest')	Quang Nam	18,977	2009	2	-	-	Recce surveys	Previously listed as 'Que Son proposed SHCA'	Rawson <i>et al.</i> 2011
Ngoc Linh - Quang Nam NR	Quang Nam	18,430	2016	6	-	-	Listening post survey	Recorded # groups was previously 13 (survey in 2005)	Vu Tien, Tran Van & Nguyen Kim 2017
Ngoc Linh - Kon Tum NR	Kon Tum	41,424	2006	≥1	-	-	Recce surveys		Rawson <i>et al.</i> 2011
Tu Mo Rong PF	Kon Tum	15,000	-	?	-	-		Newly-added as a potential area for the species	Wearn <i>et al.</i> 2021c
Kon Plong District (including Kon Plong proposed NR)	Kon Tum	80,000	2020	46	489	0.36	Spatially explicit capture- recapture from listening post survey	Recorded # groups increased from 4 (survey in 2000)	Wearn <i>et al.</i> 2021c
Chu Mom Ray NP	Kon Tum	56,621	2019	39	-	-	Listening post survey	Recorded # groups increased from 14 (survey in 2007)	Vu Tien, T., pers. comm., 2023
Kon Ka Kinh NP	Gia Lai	41,780	2016	11	37	0.11 ^b	Listening post survey and use of 'correction factors ^{'c}	Recorded # groups increased from 9 (survey in 2010)	Nguyen Ai <i>et al.</i> 2017

Dak Roong and Tram Lap SFEs	Gia Lai	14,250	2008	8	-	-	Recce and listening post surveys		Rawson <i>et al.</i> 2011
Kon Cha Rang NR	Gia Lai	15,900	2022	11	27 ^f	0.19 ^g	Listening post survey and use of 'correction factors ¹⁰	Recorded # groups was previously 13 and density 0.22 groups per km ² (survey in 2010)	Vu Tien & Dong Thanh 2015; Nguyen Van 2023
Ba To proposed NR	Quang Ngai	20,140	2016	21	67 (95% CI: 34-160)	0.41 (95% Cl: 0.21- 0.99) ^b	Listening post survey and use of 'correction factors ^c	Previously listed as 'Ba Nam Commune, Ba To District'; recorded # groups increased from 3 (survey in 2011)	Hoang Minh <i>et</i> <i>al.</i> 2023
An Toan NR	Binh Dinh	22,450	2016	25	47 (95% CI: 36-60)	0.16 (95% CI: 0.12- 0.20) ^b	Listening post survey and use of 'correction factors ¹⁰	Newly-added as a confirmed area for the species	Hoang Minh <i>et al.</i> 2023
Vinh Son and Vinh Hao Communes, Vinh Thanh District	Binh Dinh	14,000	2016	Extirpated?	-	-	Listening post survey	Newly-added as a site for the species (albeit provisionally extirpated)	Hoang Minh <i>et</i> <i>al.</i> 2023
			groups periods)	309	1,297				
		recer	roups – nt only 2011)	231	1,219				

^aBac Huong Hoa NR has variously been reported as harbouring *N. annamensis* (Nguyen Van *et al.* 2017), *N. siki* (Nguyen Dinh *et al.* 2020) or both (Hoang Minh *et al.* 2023). We here assume it is *N. siki* given its location north of the assumed range boundary (Thach Han river) but further confirmation from acoustic and genetic data is needed. ^bDensity calculated on the basis of 1.5 km listening radius, and accounting for gibbons that may be missed if they did not sing.

^cCorrection factors were used to account for the fact that some gibbons may be missed in short surveys and that some areas of suitable habitat were unsurveyed.

^dNumber of groups in Nam Dong and A Luoi excluding those in Phong Dien NR, TT Hue Saola NR and Bach Ma NP; numbers reported in Hoang Van et al. (2018) for these districts appear to be erroneous.

^eReported densities from this study of 1.46 groups per km² (within gibbon-suitable habitat) were recalculated by dividing the estimated number of groups by the area of the park to allow fairer comparisons.

^fEstimated number of groups taken from Vu Tien & Dong Thanh (2015), since the most recent survey did not extrapolate beyond their surveyed areas.

⁹Density calculated on the basis of 2 km listening radius, and accounting for gibbons that may be missed if they did not sing.

Since the last gibbon status review, pressures on the species from loss of habitat and infrastructure development have continued apace, especially in the Central Highlands (**Box 2**). On the other hand, gun hunting may be gradually declining in intensity in parts of the range of the species, as a new generation of young Vietnamese look to urban centres for employment instead of relying on natural resource extraction (Macmillan & Nguyen 2014). This may be allowing for the gradual recovery of gibbon populations in small pockets of its geographic range. For example, a downward trend in hunting (all methods of hunting) was indicated during interviews of Katu ethnic minority hunters around Quang Nam Saola NR (Macmillan & Nguyen 2014). Around Kon Ka Kinh NP, however, gun hunting appears to still be a major threat (Hoang Van *et al.* 2015; Ha Thang *et al.* 2021), perhaps reflecting cultural differences among regions, as well as variation in enforcement of laws. It seems likely that populations in Kon Ka Kinh NP and Kon Cha Rang NR are still declining, as well as those in neighbouring An Toan NR and Ba To proposed NR. In Dak Rong NR, too, declines in occupancy between 2019 and 2022 have been attributed to hunting (Vu Tien *et al.* 2023).

Only two sites within the range of *N. annamensis* have been surveyed in a consistent manner more than once, offering some information on population trends. In Kon Cha Rang NR, surveys in 2010 estimated a density of 0.22 gibbon groups per km² over the surveyed sites (Vu Tien & Dong Thanh 2015), whilst surveys in 2020 and 2022 estimated the density at 0.15 and 0.19 groups per km², respectively (Nguyen Van 2023). Ostensibly, this supports the notion that the population in Kon Cha Rang is declining. However, this remains unclear, owing to the very wide uncertainty associated with these estimates (in particular, the most recent surveys were based on just 12 listening posts). Variation in the estimates might also be due to the specific placement of the listening posts in the two studies.

In the large 'ridge to reef' landscape including the two Saola NRs and Bach Ma NP, longitudinal data on the gibbon population also exist, albeit on gibbon occupancy of sites rather than population size *per se*. These acoustic surveys, using standardised methods and robust analyses, showed that gibbon occupancy slightly declined over the three surveys done in 2012, 2014 and 2016, with occupancy estimates of 0.80, 0.74 and 0.73, respectively (Vu Tien *et al.* 2020). Given the uncertainty associated with the occupancy estimates, the authors of that study interpret these results as consistent with a stable population (Vu Tien *et al.* 2020). In Dak Rong NR, however, similar passive acoustic methods revealed a startling and clear decline in gibbon occupancy over just three years, with rates of local site extinction as high as 67% (Vu Tien *et al.* 2023). This was attributed to hunting pressures.

Overall, the outlook for *N. annamensis* is not optimistic, as most populations appear to be declining. This stands in contrast, perhaps, to the other light-cheeked *Nomascus* species in Vietnam (*N. leucogenys*, *N. siki* and *N. gabriellae*), which may have passed through their respective population bottlenecks and are showing signs of recovery in some sites.

6.4. Estimated population densities

Given the habitat degradation and hunting pressures on northern yellow-cheeked gibbon populations, it is unsurprising that estimated densities, where data are available, are low (in the range 0.11-0.58 groups per km²; **Table 6**). Estimated densities for the other light-cheeked gibbon species in Vietnam are similarly depressed (*N. leucogenys* range: 0.33-0.48 groups per km²; *N. gabriellae* range: 0.12-0.72 groups per km²), although those for *N. siki* appear marginally higher (range: 0.29-1.40 groups per km²). These densities are an order of

magnitude lower than densities reported for other gibbon genera (e.g. 1.5-2.5 groups per km² for *Hylobates* species; Cheyne *et al.* 2016).

The lowest population density estimates are from Kon Ka Kinh NP, Kon Cha Rang NR and An Toan NR (0.11, 0.19 and 0.16 groups per km², respectively), all areas thought to be under pressure from gun hunting and (in the latter two sites) large-scale logging (Vu Tien & Dong Thanh 2015; Nguyen Ai *et al.* 2017; Hoang Minh *et al.* 2023). If declines in these sites continue, populations will become increasingly susceptible to extinction, whether through hunting, stochastic effects (i.e. chance variation in the environment or in the demographics of the population), inbreeding, or a combination of these drivers. Populations in Song Thanh NP and the districts of Kon Plong and Ba To appear to have been impacted slightly less, with densities in the range 0.36 to 0.58 groups per km² (Tran Van & Vu Tien 2020; Wearn *et al.* 2021c; Hoang Minh *et al.* 2023). Although these densities are still far below carrying capacity of the areas, they might represent opportunities to recover healthy populations of northern yellow-cheeked gibbon in Vietnam.

More than 20 years ago, densities of *N. annamensis* in Bach Ma NP were estimated at 1.3 groups per km² (Geissmann *et al.* 2007), albeit from a relatively limited sample of the park (approximately 4% of the forested area). These data may be useful as a baseline of past *N. annamensis* densities, already at that time likely depressed by widespread habitat degradation during and after the Vietnam-America War.

In Cambodia, population densities of *N. annamensis* appear to be slightly higher than in Vietnam. Densities in Veun Sai-Siem Pang NP and Virachey NP were estimated using robust methods (spatially explicit capture-recapture) at 0.32 and 0.71 groups per km², respectively (Kidney *et al.* 2016; Sinovas P., pers. comm., 2020). To date, no population density estimates are available from Laos.

6.5. Recent research findings

The northern yellow-cheeked gibbon has not been the subject of any in-depth field study in Vietnam. This means that basic life-history parameters, such as group sizes, social structure and breeding rates are entirely unknown for the species. Population survey data have, however, uncovered the sensitivity of the species to forest disturbance and hunting. For example, in Kon Plong District, modelling of gibbon group density showed that canopy height was an important driver of the occurrence of the species, with most gibbon groups occurring in tall forest, with canopy heights of at least 30 m (Wearn *et al.* 2021c). Areas that had been heavily degraded, or impacted by selective logging, were largely devoid of gibbons. Similarly, in Dak Rong NR and Song Thanh NP, gibbons were found to be associated with higher forest quality, i.e. 'rich' and 'medium' forest in the Vietnamese forestry classification (Tran Van & Vu Tien 2020; Vu Tien & Doherty 2021). In the Saola NRs and Bach Ma NP, gibbons were more likely to be found in dense forest areas with high productivity (as measured using the Normalized Difference Vegetation Index; Vu Tien *et al.* 2020); they were also more likely to colonise these sites over time, suggesting that highly productive forest areas (potentially offering more fruit resources) are needed for populations to expand and recover over time.

In Song Thanh NP, gibbons were more likely to be found in areas far from villages, i.e. in the core of the park (Tran Van & Vu Tien 2020). This is a common pattern for gibbons in Vietnam and may indicate an effect either of hunting and-or human disturbance. Distinguishing between the distinct impacts of these two drivers of decline on *N. annamensis* populations

(and indeed other *Nomascus* species) is important, since a different management approach might be effective in each case. A mixed-methods approach to dissecting these two drivers of decline, combining social science and ecological data collection, might provide greater insights than either approach in isolation.

To date, the only in-depth field studies of the northern yellow-cheeked gibbon have all taken place in Veun Sai-Siem Pang NP in Cambodia, where a single group of 4-5 individuals - one adult male, one adult female and a variable number of young – has been followed since 2007 (and was considered habituated by 2011). This work has revealed that, in common with studies of N. leucogenys (Ruppell 2013), N. gabriellae (Bach Thanh et al. 2017) and the northern Nomascus species (Guan et al. 2018), activity and diet varies with the seasons, with feeding time increasing and travel time decreasing during the dry season, as individuals switch from feeding on fruits to more energy-poor leaves (Frechette et al. 2017; Hon et al. 2018). Overall, fruit composed around 60% of dietary records, which is higher than other Nomascus species and more similar to gibbon species inhabiting aseasonal forests (Bartlett 2007). The home-range over a 6-year period was 127 ha (Frechette et al. 2017), which is considerably larger than that reported for other light-cheeked Nomascus (Ruppell 2013; Bach Thanh et al. 2020), and more similar to the northern Nomascus species (Guan et al. 2018). However, gibbons are known to subtly shift their home-ranges over time (Chevne et al. 2019; Ma et al. 2020a), which means that not all of the 127 ha area was likely occupied at any given instant. Annual (or even seasonal) home-range statistics – currently unavailable for N. annamensis - might allow better comparisons across species. This study group is also the focus of a community-based tourism project, set up with the help of Conservation International. Despite more than 11 years of effort following this group, a study of their behaviour indicated that they are still wary of humans, with more time spent being vigilant, travelling and self-grooming when in the presence of tourist groups, compared to when in the presence only of guides and researchers (Williams & Behie 2020). The long-term effects of these behavioural changes (e.g. on survival and breeding rates) are as yet unknown.

6.6. Knowledge gaps

Despite recent surveys conducted to assess the status of the northern yellow-cheeked gibbon, significant gaps remain. In particular, the status of the species outside protected areas remains poorly known, most especially in the forests along the Vietnam – Laos border in Quang Nam and Kon Tum provinces. Here, there are opportunities to protect large transboundary areas of habitat for the species, in particular in Kon Tum where it borders Dong Ampham NPA in Laos. Elsewhere in Quang Nam and Kon Tum there are unprotected forests that connect to existing protected areas (e.g. Tu Mong Rong PF, connecting with Ngoc Linh NR) and populations in these areas, if managed well, might help to bolster those within the protected area network. Resurveys of the various populations in Thua Thien Hue – last surveyed nearly 15 years ago – would also be beneficial (for example in A Luoi and Nam Dong PFs).

The northern yellow-cheeked gibbon also remains unstudied in-depth in Vietnam, meaning that the basic life-history of the species remains undescribed. Even beyond Vietnam, the species remains very poorly known. This limits our ability to assess the viability of small, remnant populations and manage them effectively. The challenge remains in finding groups that are accessible and amenable to study (i.e. groups that are sufficiently unwary of humans), as well as those that can be effectively protected from hunting. Related to this, knowledge of hunting prevalence in different areas, as well as offtake rates, mean that it is

difficult to identify which populations are heading to deterministic extinction without conservation intervention.

6.7. Emerging threats

Of the four light-cheeked gibbon species, the northern yellow-cheeked gibbon appears to be under the greatest immediate threat from habitat-related and hunting pressures. The Central Highlands, historically inaccessible and poorly-developed, is now a focus of infrastructure development in Vietnam. Rural livelihoods also remain dependent on forests in many areas of the Central Highlands, putting pressure on remaining gibbon habitats. Although *N. annamensis* is relatively widely distributed, with some significant populations (including outside the protected area network), it might be on a trajectory that *N. leucogenys* followed decades earlier.

More positively, there are indications in some areas that hunting pressures may be on the decline, as dependence on forest-based resources reduces among local people living nearby to gibbons (Macmillan & Nguyen 2014). In Kon Ka Kinh NP, gun hunting of primates continues, but concerted enforcement efforts since 2016 are thought to have reduced the threat (Ha Thang *et al.* 2021).

In many areas, 'outsiders' (people from outside the province, typically) are identified by local people as significant drivers of hunting and-or trade (Luu Quang *et al.* 2010; Macmillan & Nguyen 2014). This potential dimension to gibbon hunting in Vietnam remains difficult to study, owing to the more cryptic operations of these hunters. It may be the case that any gains in reducing local hunting pressures are more than offset by increasing pressures from outside professionals. Quantitative data on hunting prevalence (including by locals and 'outsiders'), and its impact on gibbon populations, remains scarce across its range.

6.8. Conservation management

6.8.1. In-situ conservation

The northern yellow-cheeked gibbon has received relatively little in the way of targeted conservation in Vietnam, but has likely benefited from a number of landscape-scale projects, some of which have included the species as a flagship. For example, Fauna & Flora have led a primate conservation project since 2016 in Kon Plong District, primarily focussing on the grey-shanked douc langur (*Pygathrix cinerea*) but including consideration of gibbons (Wearn *et al.* 2021c). This led to systematic surveys for *N. annamensis*, educational and outreach work with local communities, and incorporation of gibbon priority areas into management plans by the major forest owners in this landscape (Thach Nham PF and the Kon Plong One Member Forest Company). The proposed PA in this District, centred on the biodiverse Ngoc Boc Mountain, is yet to be established, despite the national and international importance of the area for conservation.

Further south in Gia Lai Province (and in particular Kon Ka Kinh NP), a primate conservation and research project led by Frankfurt Zoological Society has focussed on the grey-shanked douc langur since 2007. This project has likely benefitted *N. annamensis* through improved law enforcement in PAs (including confiscation of guns), outreach among local communities, as well as long-term ecological research in the forest, which has provided protection to gibbon groups by proxy.

The most substantial investments in conservation within the range of *N. annamensis* have been made in Quang Nam and Thua Thien Hue provinces, benefitting the Saola NRs and Bach Ma NP, in particular. Since 2010, WWF and partners have implemented several landscape-scale conservation projects, which are thought to have led to reductions in hunting (in particular, snaring) and overall reduced pressures on forests in these provinces (e.g. Tilker *et al.* 2023). This has been achieved through improved PA management, more robust law enforcement, forest restoration and local livelihood diversification. Monitoring done in the landscape has shown that the northern yellow-cheeked gibbon distribution was stable over the period 2012-2016 (Vu Tien *et al.* 2020).

6.8.2. Ex-situ conservation

Seven *N. annamensis* individuals confiscated from the illegal wildlife trade are housed in the Endangered Primate Rescue Center (EPRC) in Cuc Phuong National Park. Under its current management plan, EPRC does not intend to breed or release these individuals, instead focussing limited resources on *N. leucogenys* (E. Schwierz, pers. comm., 2023). Outside Vietnam, the Laos Conservation Trust for Wildlife, north of Vientiane, houses two individuals, also confiscated from trade (J. Phan, pers. comm., 2023). These individuals have not yet been genetically confirmed as *N. annamensis* and no plans are currently in place to breed from or release these individuals.

6.8.3. Policy

The northern yellow-cheeked gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. Owing to its more recent discovery as a species, it was not listed in Vietnam's national Red Data Book (VAST 2007). The revised Red Data Book for Vietnam, currently in progress (Nguyen Dinh D., pers. comm., 2023), will include the species.

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) control the possession and use of firearms in communities adjacent to key populations of the species; 2) reduce the illegal wildlife trade of gibbons, including confiscations of captive individuals and dismantling of trade networks; 3) develop robust planning and environmental impact assessment processes for new developments in gibbon habitats; 4) carry out landscape planning, including protection of biodiversity corridors between protected areas; 5) improve protection in key protected sites through better collaboration between management and local communities, and 6) carry out research to determine the range boundaries between *N. annamensis* and *N. siki*. As for the other gibbon species, we are not aware of any specific activities or budget thus far to achieve these actions (La Quang & Le Khac 2020). NGOs and key PA management boards (e.g. in Bach Ma NP) have, however, made progress towards controlling hunting in some areas (e.g. in the Saola NRs, Bach Ma NP and Kon Ka Kinh NP; Action point 1), carrying out landscape-level planning (e.g. in Kon Plong District; Action point 4) and improving the protection of gibbon populations in key protected areas (e.g. in the Saola NRs, Bach Ma NP and Kon Ka Kinh NP; Action point 5). No significant progress appears to have been made towards Action points 2, 3 and 6.

Southern yellow-cheeked gibbon

111 -

(Nomascus gabriellae)

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6

Fast facts:

- Occurs over a large area of southern Vietnam, from Gia Lai Province to Binh Thuan Province
- Populations are fragmented and depleted, although strongholds still remain in: Cat Tien NP (300+ groups estimated); the Langbiang plateau including Chu Yang Sin NP and Bi Dup-Nui Ba NP (400+ groups estimated), and Bu Gia Map NP (120+ groups estimated)
- Recent data have shifted our understanding of the importance of Vietnam for the conservation of the species, now thought to be home to 64% of the global population
- Threats to remaining populations have apparently declined over the last decade, particularly from habitat loss and degradation (trends in hunting and trade are less certain)
- Building from successful releases of confiscated N. gabriellae gibbons back into the wild, an opportunity now exists to plan for scaled-up reintroductions and, ultimately, the long-term recovery of the species in southern Vietnam

7. Southern yellow-cheeked gibbon (Nomascus gabriellae)

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Summary

- The southern yellow-cheeked gibbon (*Nomascus gabriellae*) has a large geographic range, covering a broad swathe of southern Vietnam
- Within this range, however, populations are isolated and fragmented, with the most significant populations likely in: Cat Tien NP (and an adjacent reserve); the Langbiang Plateau (Chu Yang Sin NP, Bi Dup-Nui Ba NP and adjoining forests), and Bu Gia Map NP (and adjoining forests, including into Cambodia)
- Since the last status review, important survey data have been collected in each of the major stronghold populations in Vietnam, revealing an estimated 1,147 groups nationally; Vietnam holds 64% of the global population of the species
- Pressures on the species from habitat loss and degradation, as well as hunting and trade, have apparently declined since the last status review; however, hunting and trade may have shifted to become more cryptic over time, rather than declining (this remains to be investigated)
- The species has been the focus of more in-depth research than other *Nomascus* in Vietnam, revealing the basic ecology of the species and its importance in seed dispersal, likely a key ecosystem function of gibbons in Vietnam's forests
- The Dao Tien Endangered Primate Species Centre focusses on the rescue, rehabilitation and release of gibbons in southern Vietnam, in particular *N. gabriellae* (of which 12 individuals have been released so far); this is the only successful example of such a project in Vietnam to date and could be used as a launchpad for an ambitious effort to recover the species, and its ecological role, in southern Vietnam
- No field conservation efforts are currently focussed on the southern yellow-cheeked gibbon, although it has likely benefitted from management actions taken by a number of protected areas within its range, including in Cat Tien NP

7.1. Distribution

The southern yellow-cheeked gibbon has perhaps the largest geographic range in Vietnam of the six *Nomascus* gibbons in the country, covering parts of 10 provinces (Gia Lai, Phu Yen, Dak Lak, Dak Nong, Khanh Hoa, Lam Dong, Ninh Thuan, Binh Thuan, Dong Nai and Binh Phuoc; **Fig. 8**). The Ba River, running through Gia Lai and Phu Yen Provinces, was previously reported as the northern extent of the species (Rawson *et al.* 2011), though records of the species in A Yun Pa and Dong Xuan PF (Tran Van & Hoang Minh 2015; Tran Van, B., pers. comm., 2023), slightly north of this river, call this into question (Hoang Van *et al.* 2018). An alternative hypothesis is that temperature seasonality restricts the range of *N. gabriellae*, with annual temperature variations of more than around 1.5°C apparently favouring *N. annamensis* over *N. gabriellae* (Hoang Minh *et al.* 2023). From Gia Lai province northwards, seasonality becomes more extreme (especially in the uplands) in Vietnam,

perhaps explaining the range boundary between the two yellow-cheeked gibbon species. In the south, the species occurs almost to the limit of the country's remaining tropical evergreen and deciduous forests, in Nui Ong NR (**Fig. 8**). Further south than this reserve, the few remaining forests are composed of swamp and mangrove forest types, representing unsuitable habitat for the species.

Despite the relatively large geographic extent of the species in Vietnam, populations are highly fragmented. Just a few major blocks of habitat for the species remain, principally in:

- i) Cat Tien NP (Nam Cat Tien sector) and adjoining Dong Nai Culture and Nature Reserve
- ii) a complex of forests on the Langbiang plateau, including Chu Yang Sin NP, Bi Dup-Nui Ba NP, Phuoc Binh NP and Hon Ba NR, as well as adjacent production forests
- iii) Bu Gia Map NP and Quang Truc Commune forests (including adjoining forest in Cambodia)

Despite a number of important new surveys since the last status review in 2011 – most notably in A Yun Pa proposed NR (Tran Van & Hoang Minh 2015), Chu Yang Sin NP (Vu Tien *et al.* 2016) and the Nam Cat Tien sector of Cat Tien NP (Vu Tien *et al.* 2018a) – significant gaps in our understanding of the status of the species remain, particular within the smaller and-or more isolated forests within the species' range. This means that it is currently difficult to determine if and where certain populations might have been extirpated since the last review. In addition, much of the population data are rapidly becoming out-dated, with no population surveys reported in the last 5 years. This stands in contrast to the other Vietnamese gibbon species, for which we have a more up-to-date picture of their distribution and population status.

Beyond Vietnam, the species occurs only in south-eastern Cambodia. With the recognition of N. annamensis as a distinct species from N. gabriellae, the distribution of the latter no longer includes Laos. Two major rivers - the Mekong and Srepok - appear to define the western and northern limits, respectively, of the species in Cambodia. However, the northern limit may actually be due to the dry dipterocarp forests of eastern Cambodia – suboptimal habitat for gibbons – instead of the Srepok river per se (Rawson et al. 2011). The species is apparently well-represented in Cambodia, with approximately 500 groups estimated to be in the very large (2,927 km²) Keo Seima Wildlife Sanctuary bordering Bu Gia Map NP (Nuttall et al. 2022). The gibbon population in Keo Seima WS is estimated to be stable (and possibly increasing) over the last decade, reinforcing the importance of this site for the long-term conservation of the species. At least in part, this reflects the decreasing availability and use of firearms in the country and the consequent reduction in hunting of arboreal mammals, including gibbons (Nuttall et al. 2022). Phnom Prich WS, which neighbours Keo Seima WS, likely holds the second-most important population in Cambodia (with an estimated 57-149 groups), although much of the vast area is composed of dry deciduous forest (46% of the 2,225 km²), apparently unsuitable habitat for gibbons (Channa & Gray 2009). Threats from hunting are apparently low in Phnom Prich WS, although forest degradation is ongoing in some areas (Channa & Gray 2009; Gray, Phan & Long 2010).

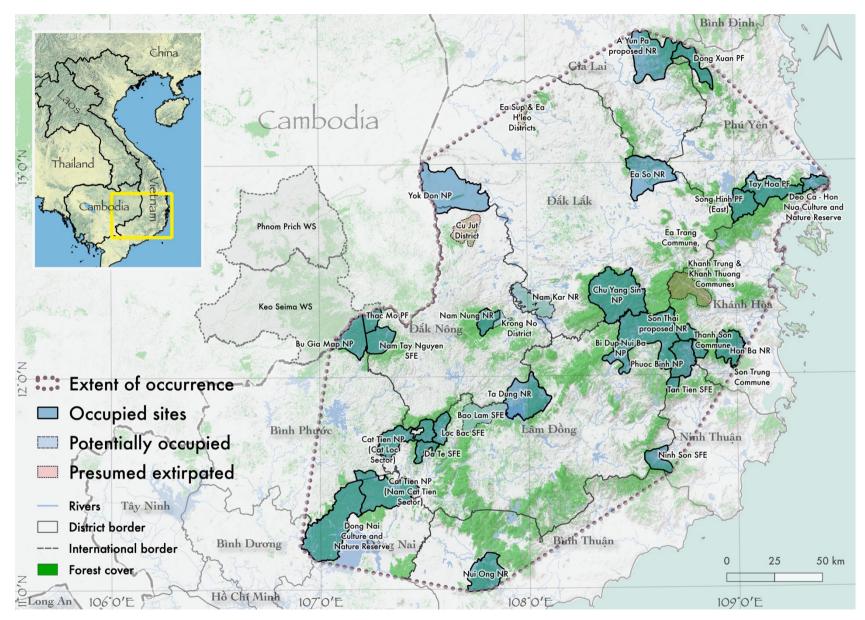


Figure 8. Extent of occurrence of the southern yellow-cheeked gibbon (*Nomascus gabriellae*) in Vietnam, showing all known, potential and (presumed) extirpated sites. Forest cover for 2022 is from the 'Global Forest Change' dataset (Hansen *et al.* 2013). Key sites in Cambodia that are mentioned in the text are also shown.

7.2. Population status

Since the last status review in 2011, population surveys have been done in each of the major stronghold areas for *N. gabriellae* in Vietnam (**Table 7**). Surveys in the Nam Cat Tien sector of Cat Tien NP supported the prevailing view that it held the largest population in any one site (likely 300+ groups; Vu Tien *et al.* 2018a). The importance of Cat Tien NP is bolstered by the fact that the Nam Cat Tien sector adjoins Dong Nai Culture and Nature Reserve, which itself has a small (and possibly expanding) gibbon population (Nguyen Manh *et al.* 2010b), and also by the fact that the management board oversees an additional population (albeit depressed) in the Cat Loc sector (Kenyon 2007; Hoang Minh & Tran Van 2021).

The importance of the Langbiang (or Da Lat) plateau forests has risen since the last review, with surveys in 2012 in Chu Yang Sin NP reporting an estimated 150+ groups (Vu Tien *et al.* 2016), and with substantial numbers of gibbons also likely to be present in adjacent Bi Dup-Nui Ba NP, Phuoc Binh NP, Hon Ba NR and surrounding SFEs (Hoang Minh, Tran Van & Covert 2015). The upland, rugged terrain on the Langbiang plateau has afforded some *de facto* protection, meaning that the forests in this region are more intact and hunting pressures have been lower than in most other *N. gabriellae* sites. A re-survey of the gibbon population in Bi Dup-Nui Ba NP (last surveyed in 2010) might help to assess if the trend for gibbons in this area is indeed positive, or at least stable. The discovery of the large population in Chu Yang Sin NP, with some groups living above 2,000 m, also confirms the ecological flexibility of *N. gabriellae*. Both lowland and upland sites therefore make important contributions to the conservation of *N. gabriellae*, as is the case for the other *Nomascus* species in Vietnam.

Bu Gia Map NP, although relatively small compared to the other high priority *N. gabriellae* sites, remains a critical site for the conservation of the species due to its transboundary connection to vast areas of habitat in Cambodia (Keo Seima WS and, in turn, Phnom Prich WS). With 120+ groups in the park, it likely represents the third most important area for southern yellow-cheeked gibbon conservation within Vietnam. The whole transboundary landscape may harbour upwards of 700 gibbon groups, making it the top priority globally for the species.

With gibbon surveys since the last status review uncovering large populations of *N. gabriellae* in Vietnam, the country is now perhaps more important for the conservation of the species than previously thought, with the majority (64%) of the global population within its jurisdiction (assuming 650 groups in Cambodia).

7.3. Population trends

Population trends for the southern yellow-cheeked gibbon have not been assessed anywhere in Vietnam, but in the last status review were thought to be declining in most sites (Rawson *et al.* 2011). This may now no longer be the case, given the reduced reliance on forest resources among rural populations in the region, and anecdotal reports of reduced gibbon hunting and trade. However, quantitative evidence to confirm this overall pattern remains lacking.

The Nam Cat Tien sector of Cat Tien NP is the only site which has been extensively surveyed twice (Kenyon 2007; Vu Tien *et al.* 2018a). Due to methodological differences, it is difficult to statistically compare the two surveys occurring 11 years apart, but the population has almost certainly increased since 2005 (Kenyon *et al.* 2011; M. Kenyon, pers. obs., 2023).

 Table 7. Southern yellow-cheeked gibbon (Nomascus gabriellae) sites in Vietnam since 2000.

Site	Province	Area (ha)	Survey year	Recorded # groups	Estimated # groups	Group density, per km ²	Survey methods	Change since last assessment	Source
A Yun Pa proposed NR	Gia Lai	44,268	2012	6	-	-	Recce surveys	Recorded # groups increased from 1 (survey in 1998)	Tran Van & Hoang Minh, 2015
Dong Xuan PF	Phu Yen	14,800	2014	≥1	-	-	Recce surveys	Newly-added as a confirmed area for the species	Tran Van, B., pers. comm., 2023
Deo Ca – Hon Nua Culture & Nature Reserve	Phu Yen	8,918	2023	1	-	-	Recce surveys	Newly-added as a confirmed area for the species	Pham, T., pers. comm., 2023
Tay Hoa PF	Phu Yen	26,449	2014	2	-	-	Recce surveys	Newly-added as a confirmed area for the species	Tran Van, B., pers. comm., 2023
Song Hinh PF (East)	Phu Yen	16,769	2014	2	-	-	Recce surveys	Newly-added as a confirmed area for the species	Tran Van, B., pers. comm., 2023
Ea Sup & Ea H'leo Districts	Dak Lak	3,800	1998	Extirpated?	-	-	Recce surveys		Rawson <i>et al.</i> 2011
Ea So NR	Dak Lak	22,000	2006	≥1	-	-	Recce surveys		Rawson <i>et al.</i> 2011
Ea Trang Commune, M'drak District	Dak Lak	350	1998	Extirpated	-	-	Recce surveys	Presumed extirpated, given the lack of new records and very small size of the remaining forest	Rawson <i>et al.</i> 2011
Yok Don NP	Dak Lak	115,545	2007	2	-	-	Recce surveys		Rawson et al. 2011
Cu Jut District	Dak Nong	15,000	2000	Extirpated?	-	-	Recce surveys		Rawson et al. 2011
Chu Yang Sin NP	Dak Lak	59,531	2012	28	166 (95% Cl: 135- 204)	0.34 (95% CI: 0.27-0.42)ª	Listening post survey and mark-recapture analysis	Recorded # groups increased from 8 (survey in 2009)	Vu Tien <i>et al.</i> 2016
Bi Dup-Nui Ba NP	Lam Dong	63,938	2010	25	-	0.29 (95% CI: 0.25-0.66) ^{bc}	Listening post survey		Rawson <i>et al.</i> 2011; Hoang Minh <i>et al.</i> 2015

Khanh Trung & Khanh Thuong Communes, Khanh Vinh District	Khanh Hoa	23,000	2014	Extirpated?	-	-	Listening post survey	Provisionally extirpated; overlaps with 'Khanh Hoa SFE and Tram Huong Forest Company' listed in Rawson <i>et al.</i> (2011)	Hoang Minh <i>et al.</i> 2015
Son Thai proposed NR, Khanh Vinh District	Khanh Hoa	6,900	2014	8	50 (95% CI: 30-85)	0.21 (95% CI: 0.15-0.42) ^b	Listening post survey and use of 'correction factors' ^d	Newly-added as a confirmed area for the species	Hoang Minh <i>et al.</i> 2015
Phuoc Binh NP	Ninh Thuan	19,814	2014	34	45°	0.50 (95% CI: 0.46-0.59) ^b	Listening post survey and use of 'correction factors' ^d	Recorded # groups increased from 4 (survey in 2009)	Hoang Minh <i>et al.</i> 2015
Tan Tien SFE	Ninh Thuan	4,200	2014	13	18 ^e	-	Listening post survey and use of 'correction factors' ^d	Newly-added as a confirmed area for the species	Hoang Minh <i>et al.</i> 2015
Thanh Son & Son Trung Communes, Khanh Son District	Khanh Hoa	5,000	2014	17	41 (95% CI: 37-50)	0.33 (95% CI: 0.28-0.46) ^b	Listening post survey and use of 'correction factors' ^d	Newly-added as a confirmed area for the species	Hoang Minh <i>et al.</i> 2015
Hon Ba NR	Khanh Hoa	20,978	2014	21	64 (95% CI: 45-87)	0.32 (95% CI: 0.25-0.48) ^b	Listening post survey and use of 'correction factors' ^d	Previously unknown # groups (survey in 2005)	Hoang Minh <i>et al.</i> 2015
Ninh Son SFE	Ninh Thuan	30,332	2014	24	53 (95% CI: 46-80)	0.38 (95% CI: 0.30-0.53) ^b	Listening post survey and use of 'correction factors' ^d	Recorded # groups increased from 6 (survey in 2007)	Hoang Minh <i>et al.</i> 2015
Nam Kar NR ^f	Dak Lak	20,500	-	?	-	-	-	Added as a potential gibbon site	Vu Tien <i>et al.</i> 2018b
Nam Nung NR	Dak Nong	10,499	2011	11	30	-	Listening post survey		Rawson et al. 2011
Krong No District	Dak Nong	3,300	1998	Extirpated?	-	-	Recce surveys		Rawson et al. 2011
Ta Dung NR	Dak Nong	18,893	2010	6	12	0.12	Listening post survey		Hoang Minh, Tran Van & Vu 2010
Thac Mo PF and Nam Tay Nguyen SFE	Dak Nong	32,018	2013	18	86 (95% CI: 59-121)	0.27 (95% CI: 0.18-0.38) ^b	Listening post survey and use of 'correction factors' ^d	Previously unknown # groups (survey in 2010); listed as 'Quang Truc Commune' in the previous review	Hoang Minh <i>et al.</i> 2014

Bu Gia Map NP	Binh Phuoc	25,926	2010	88	124 (95% Cl: 122- 132)	0.54 (95% CI: 0.51-0.58)⁵	Listening post survey and use of 'correction factors' ^d		Rawson <i>et al.</i> 2011
Bao Lam SFE	Lam Dong	20,000	-	?	-	-	-	Added as a potential gibbon site	Rawson <i>et al.</i> 2011
Loc Bac SFE	Lam Dong	34,851	2004	4	-	-	Recce surveys		Rawson et al. 2011
Da Te SFE	Lam Dong	8,000	2008	16	-	0.36	Listening post survey and use of 'correction factors' ^d	Added as a distinct gibbon site	Nguyen Xuan & Nguyen Xuan 2011
Cat Tien NP - Cat Loc Sector	Lam Dong	27,850	2005	55	-	0.52	Listening post survey	8 groups recently re- confirmed from a small survey in 2021	Kenyon 2007; Hoang Minh & Tran Van 2021
Cat Tien NP - Nam Cat Tien Sector	Dong Nai	39,627	2016	44	325 (95% Cl: 232- 455)	0.72 (95% CI: 0.51-1.00)	Distance sampling from listening posts	149 groups recorded for both sectors of the park in 2005; most recent survey in 2016 only covered Nam Cat Tien sector	Vu Tien <i>et al.</i> 2018a
Dong Nai Culture & Nature Reserve ^g	Dong Nai	100,303	2010	15	-	-	Listening post survey	6 groups recently re- confirmed from a small survey in 2021	Nguyen Manh <i>et al.</i> 2010b; Hoang Minh & Tran Van 2021
Nui Ong NR	Binh Thuan	25,468	2010	3	-	-	Recce surveys		Rawson <i>et al.</i> 2011
		Total g (all time	•	445	1,147				
		Total gr recent (post 2	tonly	219	860				

^aDensity calculated on the basis of 2 km listening radius, and accounting for gibbons that may be missed if they did not sing (using mark-recapture).

^bDensity calculated on the basis of 1.5 km listening radius, and accounting for gibbons that may be missed if they did not sing.

^cDensity calculated from a very small section of the park that was surveyed using two listening posts in 2015 (Hoang Minh *et al.* 2015). The authors were not confident in extrapolating this to the whole park.

^dCorrection factors were used to account for the fact that some gibbons may be missed in short surveys and that some areas of suitable habitat were unsurveyed.

*An estimate of the number of groups was only provided for the combined area of Phuoc Binh NP and Tan Tien SFE, but these have been split here based on an approximate 2.6:1 weighting (derived from examination of maps in Hoang Minh *et al.* 2015).

^fAlso referred to as Nam Ca NR.

⁹Previously Vinh Cuu NR, which replaced Vinh An, Ma Da and Hieu Liem SFEs.

In Cambodia, the gibbon population in Keo Seima WS has been tracked for more than 10 years, making it one of the most intensively monitored *Nomascus* populations globally. In this site, the gibbon population has shown a stable trend over time (Nuttall *et al.* 2022).

7.4. Estimated population densities

From basic ecological principles, we might predict that *N. gabriellae* population densities would be higher than the more northern *Nomascus* species which inhabit more seasonal and climatically harsh forests, with lower fruit availability (Guan *et al.* 2018). However, this does not seem to be borne out in the data: reported *N. gabriellae* densities have mostly been low (<0.4 groups per km²) and comparable to, or lower than, densities reported for *N. leucogenys*, *N. annamensis* and *N. siki*. This might reflect biases in the estimation methods, the genuine effects of past anthropogenic pressures, and-or some other ecological factor which is limiting populations.

The unexpectedly low population densities for *N. gabriellae* might reflect particularly high hunting pressures on the species. But available information, although qualitative and-or anecdotal, suggests that primate hunting has not been relatively more intense within the range of *N. gabriellae* compared to the more northern *Nomascus* species (Kenyon *et al.* 2015). Similarly, habitat degradation has been intense for all *Nomascus* species, not just *N. gabriellae* (although *N. gabriellae* habitats were perhaps more affected during the Vietnam-America war, due to Agent Orange spraying; Brockman & Harrison 2013). There may also be an ecological factor, as yet unidentified, which is naturally limiting populations.

The low density estimates for *N. gabriellae* might also, at least in part, reflect biases in the population estimation methods used for surveys of the species. Certainly, few of the density estimates for the species have been derived using robust methods, such as distance sampling or spatially-explicit capture-recapture. Instead, estimates have mostly been generated using ad-hoc assumptions about the sampling area covered by the listening posts, often using an arbitrary 1.5 or 2 km radius (Hoang Minh *et al.* 2015; Vu Tien *et al.* 2016). This approach might lead to substantial underestimation of density, especially in flat areas (where sound does not travel as far) or in rugged areas with ridges (which act as sound barriers). The exception to this was the most recent population survey done in the Nam Cat Tien sector of Cat Tien NP, which used a robust distance sampling approach (Vu Tien *et al.* 2018a). This found a density of 0.72 groups per km², which is more in line with, or slightly higher than, density estimates for many other *Nomascus* populations.

Indeed, the Nam Cat Tien sector of Cat Tien NP has the highest density of southern yellowcheeked gibbons reported for any site. This is higher, even, than the stronghold population in Keo Seima WS, where densities have been estimated at around 0.3 groups per km² (Nuttall *et al.* 2022). Given that both studies used robust methods (distance sampling), we can be more confident about directly comparing the density estimates and ascribing the differences to ecological or anthropogenic factors rather than methodological ones. In particular, gibbon densities in Keo Seima WS might be lower because the site has substantial areas of deciduous and mosaic forest, which represent unsuitable habitats for gibbons.

7.5. Recent research findings

The southern yellow-cheeked gibbon is one of the better-studied species of *Nomascus* in Vietnam, with several academic theses and research projects in Vietnam having focussed

on the species. Research in Cat Tien NP, in particular, has advanced our understanding of the feeding ecology and ranging behaviour of N. gabriellae. This work has shown, for example, that southern yellow-cheeked gibbons appear to be 'typical' Nomascus in terms of their degree of frugivory, with 43% of food items consisting of fruit (Bach Thanh et al. 2017). This relatively low proportion of fruit in the diet in Nomascus species (Ruppell 2013; Guan et al. 2018) contrasts with the more tropical gibbons (Hylobates), which often have diets consisting >60% of fruit (Bartlett 2007). Southern vellow-cheeked gibbons, in common with other Nomascus, also display dietary flexibility with season, consuming mainly fruit in the wet season (when it can represent >70% of food items) but switching to leaves in the dry season (Bach Thanh et al. 2017). This change in diet has knock-on effects on their ranging behaviour, with observations of one group showing that they travelled less and used a smaller homerange (30 ha) in the dry season when they were feeding on energy-poor leaves (Bach Thanh et al. 2017, 2020). In the wet season, when fruits dominate their diet, they spent more time travelling and ranged over a larger area (43 ha). The more northern Nomascus also show this shift in their ranging, but it is even more dramatic in these species, in particular for N. concolor (Guan et al. 2018).

Available data also suggests that the home-range of *N. gabriellae* is relatively small – approximately 40-45 ha (Kenyon 2007; Bach Thanh *et al.* 2020) – compared to the northern *Nomascus* species, and in that sense is more akin to the more tropical *Hylobates* gibbons, which also have home-ranges typically in the range 30-50 ha (Bartlett 2007; but see Cheyne *et al.* 2019). In poor-quality habitat, however, home-ranges of *N. gabriellae* can be considerably larger (e.g. up to 100 ha in bamboo forest; Kenyon 2007).

Gibbons are frequently proposed as key seed dispersers in Asian tropical forests, but information on this functional role for *Nomascus* is sorely lacking. The southern yellow-cheeked gibbon is the only *Nomascus* species in Vietnam for which this has been studied indepth. This work revealed that, for one tree species studied (Pacific walnut, *Dracontomelon dao*), gibbons were the most important seed dispersing species, due both to the very high number of fruits consumed, the relatively long distances over which seeds were dispersed (deposited in faeces mostly > 100 m from the parent) and the relatively high germination rate of gibbon-dispersed seeds (Bach Thanh *et al.* 2018). Other *Nomascus* species are likely to play a similarly important ecological role as seed dispersers, at least where populations are sufficiently abundant, although this remains to be studied.

The southern yellow-cheeked gibbon appears to have smaller group sizes than the more northern *Nomascus* species, with a mean of 4.4 (range of 3-6) reported for Cat Tien NP (Kenyon *et al.* 2011) compared to a mean of 6.6 for *N. concolor* and *N. nasutus* (Guan *et al.* 2018). In *N. concolor* and *N. nasutus*, polygynous groups with more than one female are common, whilst in *N. gabriellae* they appear rare (Kenyon *et al.* 2011; Barca *et al.* 2016). This may reflect the fact that the northern gibbons are subsisting in habitats which are at, or near to, carrying capacity and therefore there are fewer opportunities for females to establish new territories. By contrast, the *N. gabriellae* population in Cat Tien NP was likely in a state of recovery when it was studied in 2005, with vacant habitat for dispersing females to occupy. Supporting this idea, large groups have now begun to be observed in Cat Tien NP (>6 individuals, and up to 9 in one case; E. Gazagne, pers. comm., 2023). Alternatively, it may reflect a fundamental difference in the ecology of *Nomascus* species in the north and south of Vietnam. Further study of the social systems of *Nomascus* populations across a gradient of anthropogenic disturbance may help to shed light on the drivers of variation in group size and polygyny in the genus. More up-to-date information from Cat Tien NP on group size,

dispersal ages and the prevalence of polygyny would also be informative about the flexibility of *N. gabriellae* social systems in particular.

7.6. Knowledge gaps

The southern yellow-cheeked gibbon was known to be under considerable pressure from hunting and trade, including for the pet trade (Rawson *et al.* 2020), but it is unclear to what extent these pressures continue. The more obvious indicators, such as the presence of the species in markets or in confiscations by authorities, appear to have declined (authors, pers. obs.), but this might indicate more cryptic trading (e.g. online in private groups or directly between trusted contacts), as has happened in Indonesia (Nijman *et al.* 2021). This question is yet to be investigated in Vietnam, and a combination of market (including online) surveys and interviews with hunters around key protected areas may answer this.

This species is the only species in Vietnam for which there is an ongoing project to rehabilitate and release gibbons that have been rescued from the illegal wildlife trade (Kenyon *et al.* 2015). This represents an opportunity to develop best-practice guidelines for the rehabilitation and release of *Nomascus* gibbons, and to assess the costs and benefits of such an approach. Experiences with releasing *N. gabriellae*, as well as carrying out necessary post-release monitoring, might also inform discussions around the feasibility of translocating *Nomascus* gibbons from one site to another. This might be recommended, for example, to 'rescue' isolated and non-viable gibbon populations (e.g. of isolated *N. concolor* or *N. leucogenys* groups) or to re-establish populations where they have gone extinct (e.g. within the historical range of the cao vit gibbon).

7.7. Emerging threats

Threats to the remaining southern yellow-cheeked gibbon populations are apparently declining, although limited quantitative data are available to robustly assess this. In particular, habitat loss and degradation rates have declined in recent years, in part because very little undisturbed forest remains. Pressures from hunting and trade – identified in the past as a key threat to the species (Rawson *et al.* 2011, 2020) – have also apparently declined. This apparent decline in hunting and trade echoes broader trends in gibbon hunting and trade, for example in Cambodia, China and Indonesia (Nijman *et al.* 2017; Ni *et al.* 2018; McGrath & Behie 2021). However, it might also indicate that hunting and trade has become more cryptic over time; certainly the trade in other primates, such as douc langurs, continues in Vietnam (McEwan, Nadler & Nevin 2021).

In addition, many of the smaller populations, for example those in presumed marginal habitat in Dak Lak, as well as those in the provinces of Phu Yen ('Deo Ca' forest complex), Dak Nong (Nam Nung NR and Ta Dung NR) and Binh Tuan (Nui Ong NR), may be in danger of going extinct without active management. Population size data from these areas is mostly a decade or more old, and so a priority would also be to re-survey and assess the long-term viability of the populations.

7.8. Conservation management

7.8.1. In-situ conservation

The southern yellow-cheeked gibbon occurs in a number of flagship protected areas, most notably Cat Tien NP and Bi Dup-Nui Ba NP. Within these areas, conservation of the species is integrated into broader objectives around biodiversity conservation. Targeted funding for the species has not yet materialised through the National Primate Action Plan to 2025; for example, Cat Tien NP received funding for black-shanked douc langur (*Pygathrix nigripes*) and Annamese silvered langur (*Trachypithecus margarita*) monitoring, but no funding for gibbons (La Quang & Le Khac 2020). We are not aware of any conservation NGO projects focussing on the species.

7.8.2. Ex-situ conservation

Unlike for the other *Nomascus* species in Vietnam, the southern yellow-cheeked gibbon has a dedicated rescue and rehabilitation centre within its geographic range. The Dao Tien Endangered Primate Species Centre (EPSC), located on a 56 ha river island in Cat Tien NP, was established in 2008 by the Endangered Asian Species Trust in collaboration with the park management and MARD (Kenyon *et al.* 2015). For any confiscated gibbons in southern Vietnam, Dao Tien EPSC offers the potential for them to be rehabilitated and reintroduced to the wild. Indeed, Dao Tien EPSC is the only organisation in Vietnam to have attempted reintroductions of gibbons back into the wild, with post-release monitoring of individuals showing that it has been successful (Kenyon *et al.* 2015). Reintroductions follow best-practice and release sites are chosen on the basis of multiple criteria, including: habitat quality; sufficient habitat unoccupied by gibbons, protection levels and local community engagement.

Given the ongoing work with reintroductions of confiscated gibbons, the time may be ripe to consider a future large-scale and coordinated effort to recover the southern yellow-cheeked gibbon in Vietnam. With hunting apparently declining in recent years in some areas, and effective management of protected areas ever-improving, considerable areas of currently unoccupied gibbon habitat may soon be available for consideration as reintroduction sites. This would likely require an order of magnitude increase in funding for the species, as well as the establishment of a conservation breeding programme. However, it could see the southern yellow-cheeked gibbon become the first *Nomascus* species in Vietnam to reverse its fortunes, whilst also recovering the key ecosystem role that gibbons historically played in Vietnam's southern forests.

In northern Vietnam, southern yellow-cheeked gibbons are also held in the EPRC, in Cuc Phuong NP. Currently five individuals, all rescued from the wildlife trade, reside there (E. Schwierz, pers. comm., 2023). These individuals are not currently intended for breeding or reintroduction according to the current management plan and could be transferred to other institutions.

7.8.3. Policy

The southern yellow-cheeked gibbon is a nationally-protected IB species (according to Decree 84/2021/ND-CP) and is on Appendix I of Decree 64/2019/ND-CP. It was listed as Endangered in Vietnam's national Red Data Book (VAST 2007), albeit before *N. annamensis* was split from this species.

Priority actions for the species as defined under the National Primate Action Plan to 2025 (Decision 628/QĐ-TTg) were to: 1) control the possession and use of firearms in communities adjacent to key populations of the species; 2) more effectively prevent the illegal trade of

gibbons; 3) more robust environmental impact assessment for development projects that might impact gibbon populations; 4) landscape-level planning of gibbon conservation, including protection of key sites and corridors between them, and 5) participatory conservation of key gibbon sites, including collaboration between local communities and management authorities. As for the other gibbon species, we are not aware of any specific activities or budget thus far to achieve these actions (La Quang & Le Khac 2020). Much of the focus by government and NGOs has been on activities within key protected areas, such as Cat Tien NP, whilst almost all of the identified priority actions (in particular Action points 2, 3 and 4) must take place outside protected area boundaries.

8 Summary

8. Summary

8.1. Knowledge gaps for Vietnam's gibbons

Although information about the status of Vietnam's gibbons has improved considerably since the last status review, significant knowledge gaps for each species remain (**Table 8**; priority sites for future surveys are listed in **Appendix I**). It will take considerable cooperation and collaboration among NGOs, academics and government institutions (including protected area management) to make progress on filling these gaps. It will also take significant resources from government and other stakeholders, including both national and international donors. Capacity among the next generation of field primatologists will also need to be built and expanded upon, through training, scholarships for further study, and mentorship.

8.2. Key sites for gibbon conservation in Vietnam

Although the aim of this status review was not to conduct a site prioritisation exercise – for which additional data would be needed on the costs and benefits of conservation in each site – so-called 'key sites' were identified for each species. These were simply the sites that held the majority of the population of a given species. There were a total of 16 forest blocks identified (in 41 management units), which hold a combined 3,460 gibbon groups and cover a mere 8.9% (12,823 of 143,600 km²) of the combined geographic range of *Nomascus* gibbons in Vietnam (**Fig. 9**; list of sites provided in **Appendix II**). As a proactive conservation strategy, and pending a more formal prioritisation analysis for gibbon conservation, these sites are likely to be good candidates for stepped-up investment and protection.

8.3. Conclusion

There can be no doubt that Vietnam's six gibbon species are highly threatened with extinction. They have lost a dramatic proportion of their original range extents in the country (between 38.2 and 99.9% across species; **Table 9**), many local populations continue to be on a downward spiral towards extirpation, and perilously few groups remain in the case of two of the species, the cao vit gibbon (9 groups remaining) and western black gibbon (19 groups). The broader macroeconomic context is also far from optimistic in Vietnam, with protection and restoration of wild nature continuing to take a back-seat to the pursuit of economic growth.

There are, nonetheless, two more hopeful themes that have emerged in this current status review, neither of which were apparent in previous status reviews. The first of these is that surprisingly large populations continue to be discovered in Vietnam, in some cases rivalling those reported in the past from Laos and Cambodia. Vietnam, despite intense pressures on nature, still has considerable natural heritage worthy of international recognition, investment and protection. Gibbon populations in, for example, Pu Mat National Park (400+ groups), Vu Quang NP (185 groups), the contiguous Dong Chau-Khe Nuoc Trong and Bac Huong Hoa NRs (220 groups), Song Thanh NP (400+ groups) and Cat Tien NP (300+ groups) are almost unrivalled anywhere and are inarguably global conservation priorities.

Table 8. Knowledge gaps identified during this status review for each of Vietnam's six *Nomascus* gibbon species.

Gibbon species	Knowledge gaps
Cao vit gibbon <i>Nomascus nasutus</i>	 Population genetic health, including genetic diversity and relatedness among individuals within and between groups Extent of food competition with sympatric frugivores, especially macaques (<i>Macaca mulatta</i>, <i>M. assamensis</i>, and <i>M. arctoides</i>) Effective limestone restoration techniques
Western black gibbon Nomascus concolor	 Basic ecology of the species in Mu Cang Chai – Muong La to inform conservation, including demographic rates (breeding/mortality), diet, ranging behaviour, habitat requirements, and impacts of habitat degradation Robust population estimate for the Mu Cang Chai – Muong La population using the latest statistical approaches
Northern white-cheeked gibbon <i>Nomascus leucogenys</i>	 Population status in unprotected forests (SFEs and PFs), in particular along the border with Laos in Nghe An and Ha Tinh provinces Assessment of viability of small populations, based on demographic and genetic data Refinement of geographic range boundaries
Southern white-cheeked gibbon <i>Nomascus siki</i>	 Robust population estimates, especially from sites lacking survey coverage (e.g. in Truong Son SFE, Bac Huong Hoa NR and Phong Nha-Ke Bang NP) Investigation into the range boundary with <i>N. leucogenys</i>, including acoustic and genetic data
Northern yellow-cheeked gibbon <i>Nomascus annamensis</i>	 Population status in unprotected forests (SFEs and PFs), in particular along the border with Laos (Quang Nam and Kon Tum provinces) and in Thua Thien Hue province Basic ecology of the species to inform conservation, including demographic rates (breeding/mortality), diet, ranging behaviour and habitat requirements
Southern yellow-cheeked gibbon Nomascus gabriellae	 Extent of hunting and trade of the species Further development of rehabilitation and release protocols for <i>Nomascus</i> gibbons, with <i>N. gabriellae</i> as a model species

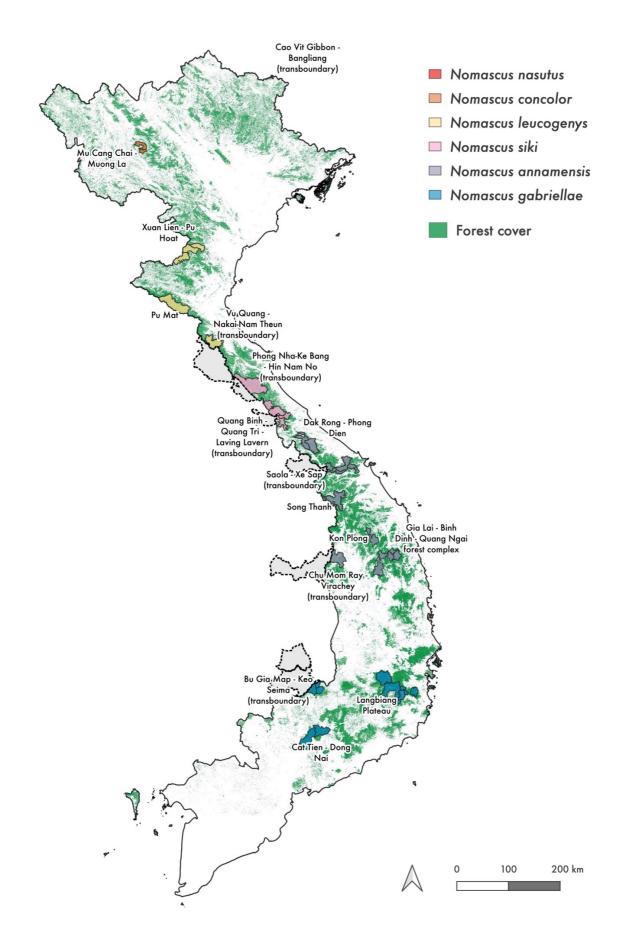


Figure 9. Key sites for the conservation of Vietnam's six gibbon species, grouped into 16 forest blocks (listed in full in Appendix II). Protected areas in Laos and Cambodia that connect with key sites in Vietnam as part of transboundary landscapes are also shown. Forest cover for 2022 was extracted from the Global Forest Change dataset (Hansen *et al.* 2013).

With the recognition of these large populations, it is clear that Vietnam plays a much more prominent role in the fate of the *Nomascus* genus of gibbons than previously thought. This is especially true for the southern yellow-cheeked gibbon, for which Vietnam is responsible for 64% of the groups that have been quantified globally. It may also be true for the northern yellow-cheeked gibbon, for which around 52% of known groups are from Vietnam (with the caveat that population sizes in Laos remain to be quantified). Added to this is the fact that 82% of remaining cao vit gibbon groups predominantly range in Vietnam.

Table 9. Extent of occurrence (EOO) and area of occupancy (AOO) for each of Vietnam's six *Nomascus* gibbon species, based on data collated in this review. EOO was calculated crudely from a minimum convex polygon around all sites identified for the species since 2000 (excluding marine areas and land outside Vietnam). AOO is the sum of the sites identified as still occupied in this review or (for the cao vit and western black gibbon) the actual area occupied as derived from population survey data.

Gibbon species	Extent of occurrence (km²)	Area of occupancy (km²)	% occupied
Cao vit gibbon <i>Nomascus nasutus</i>	6,352 ¹	8.9	0.1
Western black gibbon Nomascus concolor	5,743	75	1.3
Northern white-cheeked gibbon <i>Nomascus</i> <i>leucogenys</i>	51,412	4,012	7.8
Southern white-cheeked gibbon <i>Nomascus siki</i>	5,824	3,599	61.8
Northern yellow-cheeked gibbon <i>Nomascus</i> annamensis	26,553	5,728	21.6
Southern yellow-cheeked gibbon <i>Nomascus</i> gabriellae	47,776	6,759	14.1

¹Likely an underestimate of historical EOO if the species occurred over much of northeast Vietnam, as species distribution models suggest (Trinh-Dinh *et al.* 2022).

The second hopeful theme to have emerged from this review is that signs of population recovery are emerging from some sites for the first time. These includes the cao vit gibbon, which appears to be slowly recovering at the rate at which its habitat is regenerating. Tentative signs of population recovery are also evident in Pu Mat NP, Cat Tien NP, and Dong Nai Culture and Nature Reserve. Through concerted action to reduce hunting in the Saola NRs, populations may also be recovering there, too. Recovery may also be occurring in additional sites (such as Song Thanh NP or Dong Chau-Khe Nuoc Trong NR), for which surveys have only recently been conducted, preventing us from inferring population changes.

From these indications of population recovery there is a sense, perhaps, that the bottleneck through which gibbon populations have been forced in recent decades may soon begin to widen out again. This brings the very real possibility that, in the next review in 10 years' time, the tender green shoots of gibbon population recovery may be being discussed over a much broader set of sites.

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Appendix I. Priority sites for future population surveys.

Table A1. Priority sites for gibbon surveys from 2023 onwards. These are sites which have not been surveyed recently (after 2011) or are of high importance for a species. The three highest priorities for each species are indicated by bold lettering and an asterisk.

Site	Last survey	Justification
Nomascus nasutus		
Cao Vit Gibbon Species & Habitat Conservation Area*	2021	Surveys of this critical population are needed every <3 years
Nomascus concolor		
Hoang Lien Van Ban NR*	2009	Confirmation of status required (extirpated?)
Mu Cang Chai Species & Habitat Conservation Area*	2019	Surveys of this critical population are needed every <3 years
Muong La NR*	2019	Surveys of this critical population are needed every <3 years
Nomascus leucogenys		
Muong Nhe NR*	2010	Update on population status required
Sam Kha Commune, Sop Cop District (Sop Cop NR buffer zone)	2011	Confirmation of status required
Pu Hoat NR	2020	Full survey of this population has never been done
Pu Huong NR*	2021	Full survey of this population has never been done
Ben En NP including buffer zone	2020	Confirmation of status required (extirpated?)
Huong Son SFE & Ngan Pho PF*	2011	Update on population status required
Ke Go NR	2010	Confirmation of status required (extirpated?)
Nomascus siki		
Huong Khe PF*	Never	This site has never been surveyed for gibbons
Bong Lai SFE*	2020	Full survey of this population has never been done
Nomascus annamensis		
Phong Dien NR*	2010	Update on population status required
A Luoi District (including A Luoi PF)	2009	Update on population status required
Huong Thuy town	2009	Confirmation of status required
Nam Dong District (including Nam Dong PF)	2009	Update on population status required
Dong Giang and Tay Giang Districts	2005	Confirmation of status required (extirpated?)
Nam Giang District	2005	Confirmation of status required (extirpated?)
Thua Thien Hue Saola NR*	2010	Update on population status required
Bach Ma NP*	2009	Update on population status required

Hon Mo forest, Elephant Species & Habitat Conservation Area, Nong Son District	2009	Full survey of this population has never been done
Ngoc Linh - Kon Tum NR	2006	Full survey of this population has never been done
Tu Mo Rong PF	Never	This site has never been surveyed for gibbons
Dak Roong and Tram Lap SFEs	2008	Update on population status required
Nomascus gabriellae		
Ea So NR	2006	Confirmation of status required
Yok Don NP	2007	Confirmation of status required
Bi Dup-Nui Ba NP*	2010	Update on population status required
Nam Kar NR	Never	This site has never been surveyed for gibbons
Nam Nung NR	2011	Update on population status required
Ta Dung NR	2010	Update on population status required
Bu Gia Map NP*	2010	Update on population status required
Bao Lam SFE	Never	This site has never been surveyed for gibbons
Loc Bac SFE	2004	Confirmation of status required
Da Te SFE	2008	Update on population status required
Cat Tien NP (Cat Loc Sector)*	2005	Update on population status required
Dong Nai Culture and Nature Reserve	2010	Update on population status required
Nui Ong NR	2010	Update on population status required

Appendix II. Key sites for the conservation of Vietnam's gibbons.

Table A2. Key sites for the conservation of Vietnam's six gibbon species, as identified in the course of this status review. Key sites were defined as those holding the largest and most connected populations of each species. Sites are clustered into 16 forest blocks, of which seven are transboundary with either China, Laos or Cambodia.

Site		No. estimated groups	Justification
Nomascus nasutus			
1. Cao Vit Gibbon – Bangli	ang transk	ooundary landsca	pe
Cao Vit Gibbon Species Habitat Conservation Ar		9	Sole remaining site for the species in Vietnam and contiguous with Bangliang National Nature Reserve in China
	sub-total	9	
Nomascus concolor			
2. Mu Cang Chai – Muong	La landsc	ape	
Mu Cang Chai Species &	Habitat	14	One of only two sites in Vietnam with a
Conservation Area Muong La NR		5	population of the species One of only two sites in Vietnam with a population of the species
	sub-total	19	
Nomascus leucogenys			
3. Xuan Lien – Pu Hoat lan	dscape		
Xuan Lien NR		64	Part of a forest complex likely holding one of the largest populations in Vietnam
Pu Hoat PF		64	Part of a forest complex likely holding one of the largest populations in Vietnam
Pu Hoat NR		3	Part of a forest complex likely holding one of the largest populations in Vietnam
4. Pu Mat			
Pu Mat NP		429	Largest known population of the species in Vietnam
5. Vu Quang – Naki-Nam T	Theun tran	sboundary landso	cape
Vu Quang NP		185	One of the largest known populations in Vietnam and contiguous with Nakai-Nam Theun NPA in Laos
	sub-total	745	
Nomascus siki			
6. Phong Nha-Ke Bang – F	lin Nam N	o transboundary	landscape
Phong Nha-Ke Bang NP		80	One of the largest known populations in Vietnam and contiguous with Hin Nam No NPA in Laos
7. Quang Binh – Quang Tri	i – Laving	Lavern transbour	ndary landscape
Quang Ninh PF (West)		82	Part of a forest complex with the largest concentration of the species in Vietnam
Khe Giua SFE		99	Part of a forest complex with the largest concentration of the species in Vietnam

Dong Chau-Khe Nuoc Trong NR	146	Part of a forest complex with the largest concentration of the species in Vietnam
Bac Huong Hoa NR	74	Part of a forest complex with the largest concentration of the species in Vietnam
sub-total	481	
Nomascus annamensis		
8. Dak Rong – Phong Dien landscape		
Dak Rong NR	37	Part of a forest complex likely holding one of the largest populations in Vietnam
Phong Dien NR	26	Part of a forest complex likely holding one of the largest populations in Vietnam
9. Saola – Xe Sap transboundary lands	cape	
Saola NRs (Thua Thien Hue & Quang Nam)	27	Part of a forest complex likely holding one of the largest populations in Vietnam and contiguous with Xe Sap NPA in Laos
Bach Ma NP	13	Part of a forest complex likely holding one of the largest populations in Vietnam
Ba Na-Nui Chua NR	14	Part of a forest complex likely holding one of the largest populations in Vietnam
10. Song Thanh		3
Song Thanh NP	443	The largest known contiguous population in Vietnam
11. Kon Plong		
Kon Plong District	489	One of the largest known populations in Vietnam, albeit fragmented
12. Gia Lai – Binh Dinh – Quang Ngai fo	orest complex	x
Kon Ka Kinh NP	37	Part of a forest complex holding one of the largest known populations in Vietnam
Dak Roong & Tram Lap SFEs	8	Part of a forest complex holding one of the largest known populations in Vietnam
An Toan NR	47	Part of a forest complex holding one of the largest known populations in Vietnam
Ba To proposed NR	67	Part of a forest complex holding one of the largest known populations in Vietnam
13. Chu Mom Ray – Virachey transbour	ndary landsca	аре
Chu Mom Ray NP	39	Likely one of the largest populations of the species in Vietnam and contiguous with Virachey NP in Cambodia
sub-total	1,247	
Nomascus gabriellae		
14. Langbiang Plateau		
Chu Yang Sin NP	166	Part of a forest complex with the largest known concentration of the species in Vietnam
Bi Dup-Nui Ba NP	25	Part of a forest complex with the largest known concentration of the species in Vietnam
Phuoc Binh NP	45	Part of a forest complex with the largest known concentration of the species in Vietnam
SFEs in Khanh Vinh, Khanh Son and Bac Ai districts	109	Part of a forest complex with the largest known concentration of the species in Vietnam
Hon Ba NR	64	Part of a forest complex with the largest known concentration of the species in Vietnam

15. Bu Gia Map – Keo Seima transboundary landscape
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Sector) spe Dong Nai Culture and Nature 15 Cor Reserve pop	e of the largest known populations of the ccies in Vietnam and undergoing recovery ntiguous with one of the largest known pulations of the species and likely lergoing population recovery
Sector) spe Dong Nai Culture and Nature 15 Cor Reserve pop	cies in Vietnam and undergoing recovery ntiguous with one of the largest known pulations of the species and likely
. Cat Tien – Dong Nai landscape	
the con Quang Truc Commune forests 86 Par	t of a forest complex likely holding one of largest populations in Vietnam and tiguous with Keo Seima WS in Cambodia t of a forest complex likely holding one of largest populations in Vietnam





