Supplementary information

Tiger (*Panthera tigris*)

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GLOBAL TIGER POPULATION

We estimate global Tiger numbers by summing individual country estimates (Table 1). Methods for each country estimate, as well as distribution and population trends in those countries, are described below.

Table 1: Estimates of Tiger numbers by country. Methods for each country are described in the text below and in references cited.

Country	Country estimate	Year*	Trend	Source
Russia	386 [265–486]	2015–2020	stable	See below: Russia - Population
China	~ 20	2020	increasing	See below: China - Population
Thailand	145–177	2020	increasing	See below: Thailand - Population
Myanmar	>22	2018	declining	MONREC (2020).
Malaysia	< 100	2018	declining	See below: Malaysia - Population
Indonesia	393 [173–883]	2004–2018	declining	See below: Indonesia - Population
Nepal	235 [220–274]	2018	Stable or increasing	DNPWC and DFSC (2018)
Bhutan	103 [89–124]	2014	stable	DoFPS (2015)
Bangladesh	114 [89–146]	2018	unknown	Aziz *et al*. (2018)
India	2,967 [2,603–3,346]	2018	unknown	Jhala *et al*. (2020)
Cambodia – Lao PDR – Viet Nam	0	2015–2020	extirpated	See below: Cambodia, Lao and Viet Nam
Total	**4,485 [3,726–5,578]**			
Total mature individuals**	**3,140 [2608–3905]**			

*Time–span over which data were collected.

**70% of the total estimate. Mature individuals are defined in the IUCN Red List Categories and Criteria.

Table 2. Estimated percent decline in tiger numbers over three generations and potential IUCN Red List classification based on the percent decline.

Baseline estimates	Current Tiger population estimate					
	Lower limit 2,608 Tigers	Red List Category	Current estimate 3,140 Tigers	Red List Category	Upper limit 3,905 Tigers	Red List Category
Seidensticker (1999) 5,000 Tigers	48%	VU	37%	VU	22%	NT
Seidensticker (1999) 7,000 Tigers	63%	EN	55%	EN	44%	VU
Nowell and Jackson (1996) 8,262 Tigers	68%	EN	62%	EN	53%	EN

SOUTH ASIA

India

Distribution

Tigers are distributed across five landscape complexes in India; the Shivalik Hills and Gangetic Plains, the Central Indian and Eastern Ghats, the Western Ghats, the North East Hills and Brahmaputra Plains and the Sundarbans (Jhala *et al*. 2008; 2011a,b; 2015; 2020). Historically, Tigers occurred across most of the country but have been extirpated across vast areas since 1850's (Qureshi *et al*. 2006, Mandala 2018). Since 2006 All India Tiger Estimation (AITE) surveys have been carried out every four years by the government (Jhala *et al*. 2008, 2011b, 2015, 2020). The most recent assessment (2018; Jhala *et al*. 2020) estimates that 88,985 km² of forested habitat across the country is occupied by Tigers. While the study also suggests that Tiger occupancy has likely remained constant between 2014 and 2018, direct comparisons to prior estimates of occupied habitat are confounded by methodological changes (e.g. changing forest cover base layers, poor sampling especially in the north east hills landscape). Nevertheless, in 2006 it was estimated that Tigers occupied 93,697 km², followed by a decline to 81,906 km2 in 2010 attributed to declining Tiger occupancy outside protected areas, and an increase to 89,164 km² in 2014 (Jhala *et al*. 2008, 2011b, 2015). While further multi–year analysis of Tiger occupancy data highlights that in three of the landscape complexes local colonization and extinction events characterize spatial dynamics, changing sampling area from 2006 to 2018 make it difficult to draw reliable inferences (Jhala *et al*. 2020).

In recent years, records of Tigers in the high altitudes (1,500 to 4,300 m) of the Indian Himalayas have been obtained (Global Tiger Forum 2019). Future surveys in the Himalayas could result in additional distributional records and an expansion of known occupied habitat in India.

Population (trend: unknown)

The fourth edition of the AITE surveys in 2018 estimated the overall Tiger population in India to be 2,967 (SE range 2,603 to 3,346). The sampling in 2018 spanned 26,838 trap locations across 121,337 km² of effective sampling area, resulting the photo–capture of 2,461 individual Tigers (>~1 year of age). While this may represent the most comprehensive survey to date, and serve as a new baseline,

government reports claim that the population has recovered at a rate of 6% per annum since 2006 (Jhala *et al*. 2020). From 2006 to 2018, across four editions of AITE surveys, the reported Tiger population has grown from 1,411 (SE range 1,165–1,657) in 2006 to 1,706 (1,507–1,896) in 2010, 2,226 (1,945–2,491) in 2014 and 2,967 (2,603–3,346) in 2018. However, several methodological concerns preclude reliable estimates of trend (Karanth *et al*. 2011; Gopalaswamy *et al*. 2015, 2019; Harihar *et al*. 2017; Mazoomdaar 2019).

Firstly, in 2006, the authors of the 1st AITE report state that "Estimating Tiger numbers over such vast geographical areas with precision is a daunting task. Herein we attempt to provide estimates of Tiger numbers, however, we caution that due to the large variances associated with these numbers they cannot be used for monitoring Tiger status" highlighting that their estimate of 1,411 Tigers should not be used as a baseline (pp 144; Jhala *et al*. 2008). Nevertheless, this estimate is used in future assessments to claim an increase in Tiger numbers. Further, the sampling method used to estimate Tiger numbers (Jhala *et al*. 2011a), was shown to be unreliable, unless under very specific sampling and analytical constraints (Gopalaswamy *et al*. 2015). Between 2006 and 2010, AITE surveys claimed a drastic reduction in Tiger occupancy, yet claiming an increase in Tiger numbers, in contrary to established occupancy–abundance relationships (Holt *et al*. 2002, Karanth *et al*. 2011). Later between 2010 and 2014, drastic differences in analytical and sampling methods amounting to doubling in the number of sampling sites, 538% (+7,642) increase in trap locations, 301% (+240,691) increase in trap nights resulting in 144% more Tigers being photo–captured likely resulted in the observed 30% increase in Tigers (Harihar *et al*. 2017). These sampling inconsistencies have perpetuated in 2018 as well, with a near tripling of sites sampled using camera traps resulting in 295% (+171,762) increase in trap locations resulting in 64% more Tigers photo–captured. Additionally, an investigative report highlighted that errors in individual identification of Tigers could have resulted in an overestimation of Tigers during the 2014 surveys as one in seven may have been misidentified (Mazoomdaar 2019). Based on the aforementioned issues, we conclude that it is impossible to infer countrywide increases in Tiger abundances.

Conservation activities

Government leadership for Tiger conservation in India dates back to 1973 when Project Tiger was established to stem the species decline and protect the species across its habitats in India. Government and political support for Tiger conservation remain integral in India today. These efforts are steered by the National Tiger Conservation Authority (NTCA), whose chairperson is the Minister for Environment, Forest & Climate Change. In addition to the representation of senior members of the Indian Forest Service, NTCA members also include three members of Parliament, experts from the conservation sector and Secretaries from the Ministry of Tribal Affairs and Ministry of Social Justice and Empowerment. The NTCA's mandate includes monitoring Tigers, co–predators, prey and habitats, evaluating management effectiveness, extending effective law enforcement monitoring through the Monitoring System for Tigers– Intensive Protection and Ecological Status (MSTrIPES), extending financial support to Tiger Reserves, constituting a Special Tiger Protection Force, International cooperation with other Tiger range countries, steering voluntary village relocations, facilitating Tiger translocation initiatives and maintaining a database of Tiger mortalities. In addition, the NTCA has constituted high–level committees to review Tiger extinction and drives initiatives on ecosystem valuation, corridor mapping and human–wildlife conflict mitigation. Leadership from this nodal Tiger conservation agency for Tiger conservation has been instrumental in creating 51 Tiger Reserves in the country, many of which support sizable populations and the world's highest densities of wild Tigers. In recent years, there has been an increasing focus on extending resources and planning for Tiger conservation beyond the Protected Area network, including through the implementation of CA|TS (Conservation Assured Tiger Standards; Dudley *et al*. 2020). Tiger conservation within and beyond

protected area boundaries is implemented primarily by the Forest Departments of 17 states in which Tigers are distributed.

For the past five decades, NGO support for diverse aspects of Tiger conservation in India has complemented and catalysed the Government's initiatives and interventions. NGO and civil society contributions to Tiger conservation have included supporting the protection, and population recovery efforts (Harihar et al., 2018) and Assistance in the implementation of a Monitoring System for Tigers–Intensive Protection and Ecological Status (MSTrIPES) and other LEM approaches to make patrolling systems more effective. NGOs have also collaborated extensively to monitor Tiger and prey populations and habitats and have led the development, implementation and communication of scientific monitoring protocols and data analysis methods (Karanth 1998, 2006). Further support has been extended to strengthen community institutions for natural resource management, assistance with gaining tenure security, and promote participatory conservation through livelihood diversification, implementing HWC compensation, improving market access for local produce, bespoke training, skill development, capacity building of local committees and voluntary protection groups, and support in the aftermath of calamities. NGO and academic voices have also questioned and debated Tiger conservation paradigms, suggesting alternatives (Kabra *et al*. 2021). Other NGO engagements have included enabling the development of Corridor Conservation strategies, support on incorporating Smart Green Infrastructure and sustainable agricultural practices measures to ensure wildlife movement in critical wildlife corridors, and advocacy and litigation for corridor restoration. NGOs and academic groups have also been active in designing, implementing and assessing human–wildlife conflict mitigation interventions and documenting the diverse ways in which communities coexist with Tigers and other wildlife. Academic institutions in India have supported Tiger conservation through research, and over the years, important insights have been generated to guide recovery and conservation planning (Malvia *et al*. 2018, Thatte *et al*. 2018, Khan *et al*. 2021). Finally, NGO and civil society bodies have contributed substantially to environmental education and awareness programs, and such outreach has helped build and enlarge the constituency for Tiger conservation. The global reach of such organizations has brought monetary and other support for Tiger conservation in India and helped raise the species' profile.

Bhutan

Distribution

Tigers are distributed through most of the country between the altitudinal ranges of 100 to 4,500 m. However, they are mostly concentrated in north–western, central and south–central regions. Tiger photographs and signs have more recently been detected from areas like Bumdeling Wildlife Sanctuary, Jigme Khesar Strict Nature Reserve, Samtse Forest Division and Tashigang Forest Division; places where Tigers were not recorded during the nationwide Tiger survey of 2014–2015 (DoFPS 2015, Tandin *et al*. 2018; Thinley *et al*. 2021, 2020).

The first national survey for Tigers conducted in 1988 was based on social surveys and anecdotes and highlighted the presence of Tigers across most of the country (Dorji and Santiapillai 1989). A subsequent sign survey from 1996 to 1998 confirmed the presence of Tigers across north–western, central and south–central regions of the country (McDougal and Tshering, 1998). In 2014–2015, systematic photographic capture–recapture surveys were conducted across the country (DoFPS, 2015). These data were also used to assess Tiger occupancy across the country. The study estimates that Tigers occupy 33.5% of the survey area of 28,225 km² (Penjor *et al*. 2019b, 2019a).

Population (trend: stable)

In 2014–2015, Bhutan systematically surveyed their Tiger population using photographic capture–recapture sampling, creating the first reliable baseline for Tigers in Bhutan (DoFPS 2015). The survey estimated a density of 0.46 Tigers/100 km² for the survey area of 28,225 km², resulting in a population estimate of 103 (89–124) Tigers. Further analysis of the data accounting for terrain and anthropogenic influences resulted in an estimate of 91 (81–105) Tigers (Tempa *et al*. 2019).

In 1988, Dorji and Santiapillai (1989), estimated a population of 150 Tigers across the country based on interview surveys. A decade later, McDougal and Tshering (1998), estimated a population of 67–81 adult Tigers or 115–150 total Tigers which included the sub–adults and cubs based on pug mark analysis. While these priori estimates are not comparable to the current (2015) estimate of Tigers, it is likely that Tiger populations have remained stable over the last two decades.

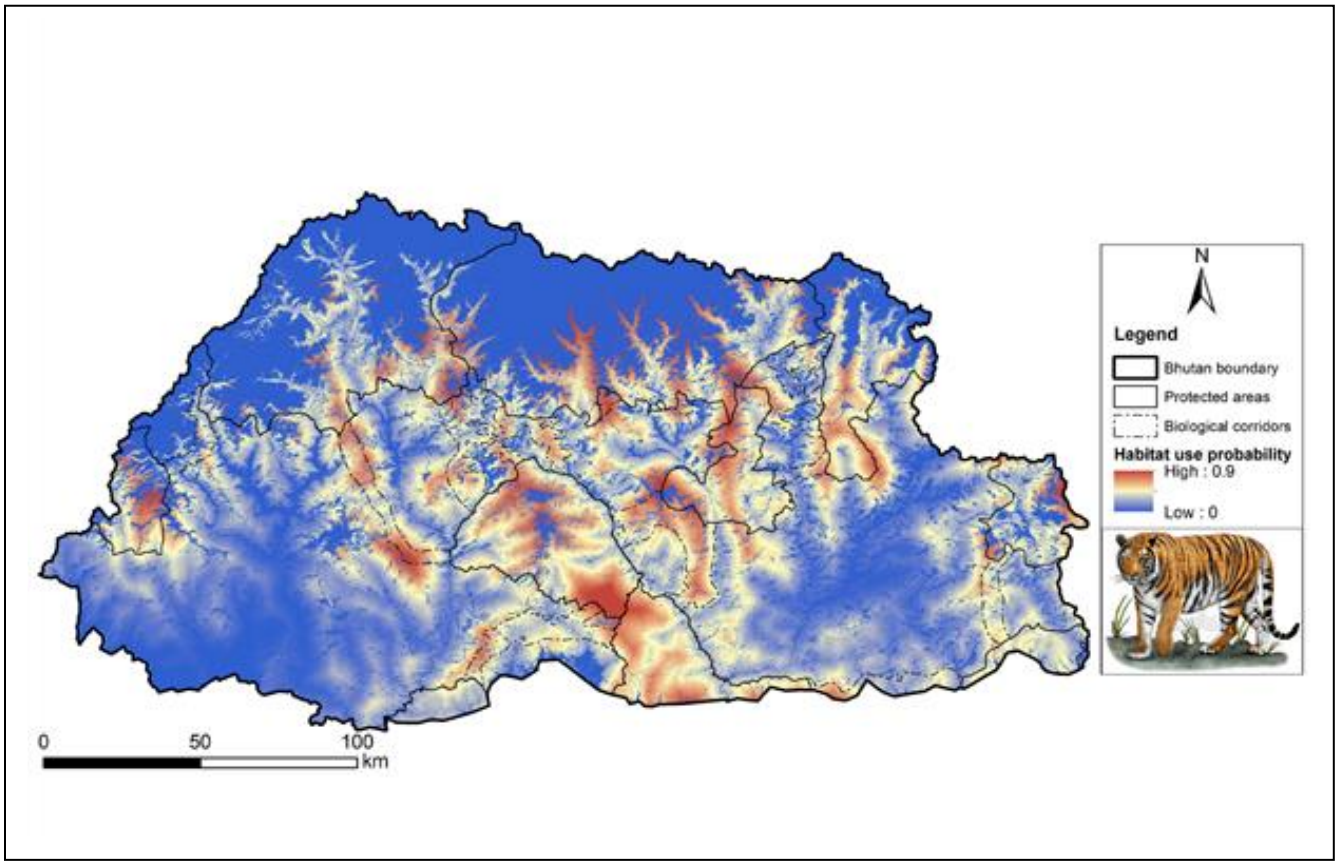

Figure 1. Nation–wide habitat use probability of Tigers in Bhutan. Map from (Penjor *et al*. 2019b).

Conservation activities

More than half of the total land area of Bhutan is protected. This, combined with a constitutional mandate to secure at least 60 percent forest cover in perpetuity, offers one of the best chances for conserving wild Tigers in the Himalayas. In 1952, the Department of Forests was established, and in 1969, the Forest Act was passed, which set up a legal framework for conservation. Bhutan developed and implemented the Tiger Action Plan from 2006 to 2015, much of which was part of the Global Tiger Initiative National Tiger Recovery Program (NCD, 2005; https://globalTigerforum.org/wp–content/uploads/2019/01/ACTION–TIGER–4th–EDITION–1.pdf). This initial plan had three major

themes: species conservation, habitat conservation, and human–wildlife conflict management. A fourth section focused on creating enabling environments, including education and awareness, regional cooperation, and human resource development was added to help implement the plan. A national Tiger survey was conducted, and the results fed into the revision of the second action plan (DoFPS 2015).

The second action plan (2018–2023 revised the goal from maintaining a connected population of breeding Tigers in Bhutan existing predominately on wild prey with minimal human–Tiger conflict, to a target–orientated goal of increasing the Tiger population by 20 percent from 2015 to 2022 (NCD 2018). The plan was expected to be achieved by:

(a) Reducing poaching of Tigers and their prey by strengthening anti–poaching using SMART patrolling and zero poaching strategies across all field offices, building staff capacity, coordination amongst different agencies, infrastructure and equipment development, and improving communication, awareness and advocacy and transboundary coordination.

(b) Improving habitat through active management, zoning and delineating critical Tiger habitats both within and outside protected areas, using smart green infrastructure for developmental activities in critical habitats and using the CA|TS standards of evaluating the performance of some protected areas.

(c) Mitigating and preventing human–Tiger conflict through awareness, improved livelihood opportunities, and construction of physical barriers. More specifically, by establishing Gewog (community–based) Tiger conservation Tshogpa (GTCT) and Tiger Quick Response Teams in nine Gewogs spanning six Dzongkhags. The GTCT is an integrated site–based approach to provide an appropriate compensation mechanism that will minimize financial losses against livestock killed by Tigers, while promoting decentralized local governance and community ownership to resolve and manage human–Tiger conflict.

(d) Guiding Tiger conservation needs through good scientific data and information, with periodic assessments of the Tiger population and distribution. The second edition of the national Tiger survey and annual Tiger monitoring of Tigers and prey in four Tiger sites will be completed in 2022.

Tiger conservation in Bhutan is funded by the Royal Government of Bhutan, the Bhutan for Life project and other donors. Additionally, a Bhutan Tiger Centre has been created to provide support to protected areas and policy makers with regards to Tiger conservation in the country.

Nepal

Distribution

Tigers are primarily distributed across the Terai and Churia habitats of southern Nepal. While historically Tigers would have been distributed across higher altitudes, it is believed that for over a century, populations have been mainly confined to lowland habitats (below 1,000 m elevation) owing to intensive human settlement patterns in the middle Himalayas that have reduced cover and prey to the extent that Tigers were extirpated from these regions (Smith *et al*. 1998). However, recent surveys have detected the presence of Tigers at higher altitudes, e.g. 2,500 m of Dadeldhura districts of western Nepal and 3,165 m of Panchthar–Ilam–Taplejung (PIT) area of eastern Nepal (Bista *et al*. 2021, Global Tiger Forum 2019). Future surveys in the middle Himalayas could result in additional distributional records and an expansion of known occupied habitat in Nepal.

Presently, the primary Tiger habitats in Nepal are the Terai habitats found along the foothills of the Himalayas. This comprises riverine forests, rich alluvial grasslands in the valleys, and tropical deciduous forests on the slopes of hill tracts. Although this belt of lowland forest runs the length of Nepal, it is fragmented, creating a metapopulation structure for Tigers (Karmacharya *et al*. 2018, Smith

et al. 1998, Thapa *et al*. 2018). Assessments as early as Smith et al. (1998) suggest that the eastern forests beyond the Baghmati river supported poor forest quality. Hence subsequent assessments focused on evaluating Tiger habitat occupancy in the lowland forests between the Baghmati river in the east and Nepal's western boundary (Barber–Meyer *et al*. 2013, Dhakal *et al*. 2014, DNPWC and DFSC 2018). Systematic occupancy surveys have been conducted on three occasions. In 2008–2009, it was estimated that Tigers occupied 5,049 km² (36%) of the 13,915 km² potential habitat surveyed (Barber–Meyer *et al*. 2013). By 2013, it was estimated that the area occupied increased to ~7,600 km², encompassing 55% of surveyed habitat; (Dhakal *et al*. 2014). Subsequently in 2017–2018, with an increase in sampling area to 16,261 km², the area occupied by Tigers increased to 11,057.5 km², 68% of the surveyed habitat (DNPWC and DFSC 2018). While the rapid recovery of Tigers within protected areas is likely partially responsible for the increases in Tiger numbers and area occupied (DNPWC and DFSC 2018, Lamichhane *et al*. 2018), high transboundary connectivity suggests that Indian protected areas likely also played an important role in initiating and sustaining recoveries (Thapa *et al*. 2017). Despite these increases, results of the recent survey highlight that Tiger occupancy is primarily concentrated within the five protected areas of the region: 6,828 km²; or 98% of surveyed habitat within protected areas is occupied, whereas 5,576 km²; or 60% of habitat surveyed outside PA's was occupied.

Population (trend: stable or increasing)

Systematic nationwide Tiger population estimation surveys using photographic capture–recapture sampling have been conducted since 2008–2009 (Karki 2011). From 2009 to 2018, the population of Tigers has reportedly increased from 121 (100–191) to 235. During this period there has been a 2.45x increase in the number of sampling locations, 2.7x increase in trap effort, and 2.8x increase in the effectively sampled area resulting in 2.45x increase in the number of individuals photo–captured (Table 2). The increasing sampling effort is likely a significant contributor to the increase in population estimates. Nevertheless, the estimates from 2018 likely represent the best estimates of Tiger numbers for the country.

Although it is likely that changes in sampling have resulted in an improved baseline estimate for the country, some populations are showing signs of recovery (DNPWC and DFSC 2018, Lamichhane *et al*. 2018, Thapa *et al*. 2017). In particular, the relatively newer protected areas of Banke and Parsa have registered density increases of 8.6x (increasing from 0.16 to 1.38 Tigers/100 km²) and 2.3x (from 0.65 to 1.49 Tigers/100 km²) between 2013 and 2018 (DNPWC and DFSC 2018). Banke and Parsa are relatively new protected areas established adjacent to Tiger population source sites of Bardia and Chitwan, respectively. Studies highlight that these recoveries are likely initiated and sustained by Tigers emigrating from these sources (Lamichhane *et al*. 2018). Additionally, parts of Shuklaphanta and Bardia have also witnessed recoveries since 2009 (Bhatta 2021, Thapa *et al*. 2017). However, it is likely that these recoveries are sustained by emigrations from Indian protected areas that lie to the south of these protected areas within the Transboundary Terai landscape.

In conclusion, the current estimate of 235 is likely the most robust baseline available for the country. Tiger populations in Nepal have likely remained stable or have witnessed recoveries in the last decade. No comparable baseline exists from 2000.

Conservation activities

In Nepal, Tigers are protected under the National Parks and Wildlife Conservation Act of 1973. The Nepal Biodiversity Strategy and Action Plan (NBSAP) 2014–2020 prioritizes protecting the Tiger. Nepal's first Tiger Conservation Action Plan (TCAP) was prepared in 1999 and revised in 2007. Following the Government of Nepal's endorsement of the Terai Arc Landscape in 2001, the National

Parks and Wildlife Conservation Department and the Department of Forests have developed various conservation and restoration activities across these five protected areas, including their buffer zones, ecological corridors and transboundary linkages that facilitate dispersal of Tigers. Between 20082012, the second TCAP was developed and implemented. During this time, the government created a National Tiger Recovery Program (NTRP) in keeping with St. Petersburg's 2010 pledge, and between 2016–2020 a revised TCAP was developed and implemented (DNPWC 2016; https://globalTigerforum.org/wp–content/uploads/2019/01/ACTION–TIGER–4th–EDITION–1.pdf).
Currently, a fourth TCAP is being developed. Since the Terai Arc Landscape is the primary Tiger habitat, the TCAPs were created to protect the metapopulation by maintaining connectivity among all protected areas, including the Indian protected areas. The strategic actions in the TCAPs include:

- improving and restoring critical Tiger habitats and corridors;
- managing grasslands and wetlands that are vital for Tigers and their prey;
- combatting Tiger crime through effective law enforcement;
- engaging with local communities in resolving human–Tiger conflicts;
- strengthening cooperation at national, transboundary, regional and international levels; and
- strengthening Tiger and prey monitoring and research.

Table 3. Changes in sampling across national surveys in Nepal.

Sampling sites	2009				2013				2018				Changes in sampling			
	Camera points	Trap Night	Effective sampled area	# unique Tigers captured	Camera points	Trap Nights	Effective sampled area	Number of unique Tigers captured	Camera points	Trap Nights	Effective sampled area	Number of unique Tigers captured	Camera points	Trap Nights	Effective sampled area	Number of unique Tigers captured
Shuklaphanta WR	113	1,679	444	7	88	1,320	385.6	13	252	4,604	2,154.3	15	2.2	2.7	4.9	2.1
Bardia NP	197	2,944	1,896	16	238	3,570	1,143.1	44	323	5,479	2,832.8	77	1.6	1.9	1.5	4.8
Chitwan NP	263	3,920	1,987	59	365	5,475	2,625.9	78	509	8,433	2,281.1	85	1.9	2.2	1.2	1.4
Parsa WR	97	1,762	353	4	177	2,655	801.8	4	305	4,810	3,634.5	15	3.1	2.7	10.3	3.8
Banke NP					118	1,770	687.4	3	254	4,503	2,311.7	17	2.2	2.5	3.6	5.7
Total	**670**	**10,305**	**4,680**	**86**	**986**	**14,790**	**5,644**	**142**	**1,643**	**27,829**	**13,214**	**209**	**2.45**	**2.70**	**2.82**	**2.43**

NGOs in Nepal have supported Tiger conservation for five decades, complementing and accelerating government initiatives (NTNC 2020). Contributions from NGOs include support for site protection by providing equipment, park infrastructure and capacity building of staff, supporting the implementation of Real–Time SMART patrolling across all five protected areas within known Tiger range in the country, supporting reformation, mobilization, capacity building, of community–based anti–poaching units, and supporting enforcement agencies, park authorities, judiciary bodies, local communities, and non–conventional partners in various sectors including capacity enhancement and provision of technology to control wildlife crime. In addition, NGOs support community–based green enterprises, livelihood diversification, predator-proof fencing and corrals in corridor and buffer zones, and training, equipment, and support to Rapid Response Teams in high Tiger conflict areas. NGOs also support local governments to manage invasive plants in community forests, reintroduce herbivores, implement Conservation Assured Tiger Standards (CA|TS), and advise on Smart Green Infrastructure (SGI) measures to ensure wildlife movement in critical wildlife corridors. Additionally, NGOs and national and international research organizations help build capacity of park staff, citizen scientists, wildlife technicians and civil society in wildlife monitoring and conservation, and support landscape–level conservation planning and decision making (e.g. Wikramanayake *et al*. 2004, Thapa *et al*. 2018). Finally, most of the Tiger conservation budget comes from the government's budget for DNPWC and DoF, while additional support comes from WWF Nepal, NTNC, ZSL Nepal, and other conservation partners.

Bangladesh

Distribution

Tigers are primarily distributed in the Sundarban Mangroves of southwestern Bangladesh, shared with India (Reza *et al*. 2000). In addition, records suggest occasional Tiger presence in the mixed–evergreen forests of the Chittagong Hill Tracts (CHT) in the southeast (Chakma 2017, Creative Conservation Alliance 2016). Classed as a Restoration Landscape (Sanderson et al. 2006), the CHT spanning 6,800 km² has the potential to support a significant sub–population of Tigers in Bangladesh (Chakma 2017, Reza and Hasan 2019). Currently, the Sundarbans remain the priority Tiger conservation landscape (Aziz *et al*. 2019, Dey *et al*. 2015), yet recent predictions indicate that Tiger habitat in the Sundarbans will be mostly lost to sea–level rise within the next 30–50 years (Mukul *et al*. 2019). There are currently no plans to facilitate the recovery of mangroves inland as sea–level rises. If these predictions are correct, recovery of Tigers in the CHT will be critical if Bangladesh is to retain a viable population of Tigers.

Khal, or riverbank, surveys in the 6,000 km² Sundarbans landscape since 2001 highlight that Tigers occur across the entire landscape (Aziz *et al*. 2019, Dey *et al*. 2015, Hossain et al. 2018, Khan 2004, Rahman *et al*. 2012). However, studies suggest that between 2007 and 2011, the index of relative Tiger abundance (Tiger track sets/km of khal surveyed/sample unit) declined by 41% (Hossain *et al*. 2018).

Population (trend: unknown)

Systematic Tiger population estimation surveys using photographic capture–recapture sampling across the Sundarbans have been conducted since 2014–2015 (Aziz *et al*. 2019, Dey *et al*. 2015). Across the two surveys conducted in 2014–2015 and 2016–2018, the population of Tigers appears to be stable and range between 106 (84–130) to 114 (89–146). Despite changes in the sampling–area across the surveys, Tiger densities at the level of sampling blocks and across the landscape are comparable between 2014–2015 and 2016–2018 (Table 3). Additionally, the population size of Tigers in the Bangladesh Sundarbans has also been estimated to be 121 (84–158) using non–invasively collected genetic data within a spatial capture–recapture framework (Aziz *et al*. 2018).

Table 4. Changes in sampling across national surveys in Bangladesh.

Sampling sites	2014-2015			2017-2018			Changes in sampling		
	Camera points	Sample area	Number of unique Tigers captured	Camera points	Sample area	Number of unique Tigers captured	Camera points	Sample area	Number of unique Tigers captured
Satkhira	71	336	13	253	1,208	36	3.56	3.60	2.77
Khulna	124	588	7	96	165	4	0.77	0.28	0.57
Sarankola	71	309	18	187	283	23	2.63	0.92	1.28
Overall	**266**	**1,233**	**38**	**536**	**1,656**	**63**	**2.02**	**1.34**	**1.66**

One estimate based on data from 2005–2007 suggested that the Bangladesh Sundarbans supported 440 (335–500) Tigers (Barlow 2009, GTRP 2010). However, a more representative photographic capture–recapture sampling across the Sundarbans during the same time interval estimated a population of ~200 Tigers (Khan 2012). Results from photographic capture–recapture sampling and Khal surveys suggest that Tiger numbers have likely declined in the Sundarbans over the last 15 years.

Conservation activities

The Bangladesh Wildlife Order, 1973 and the Bangladesh Wildlife Preservation Amendment Act, 1974 provide legal protection for Tigers. In addition, the Bangladesh Wildlife Conservation Master Plan (BWCMP), 2015–2035 and Bangladesh National Conservation Strategy (BNCS), 2016–2031, prioritize protecting Tigers. Bangladesh's first Tiger Action Plan was developed and implemented between 2009 and 2017 (Ahmad *et al*. 2009). The country also developed a National Tiger Recovery Plan aligned with the Global Tiger Recovery Program (https://globalTigerforum.org/wp–content/uploads/2019/01/ACTION–TIGER–4th–EDITION–1.pdf). Currently, the country is implementing the second Tiger Action Plan (TAP) for 2018–2027. The Sunderbans are the country's priority Tiger conservation landscape, and efforts are underway to protect and recover the Chittagong Hill Tracts. The second TAP identifies four priority goals to address the threats to Tigers and six goals to address the challenges to implementation.

Goals to address threats include:

- Increase Tiger density in the Sundarbans from 2.17 to 4.50 Tigers per 100 km².
- Maintain sufficient prey base (i.e. large prey density at least 500 times higher than Tiger density) to support the Tiger population in the Sundarbans.
- Maintain sufficient habitat and habitat diversity to support Tiger and prey populations in the Sundarbans.
- Ensure a suitable Tiger population in the Chittagong Hill Tracts.

Goals to address challenges include:

- Mainstream Tiger conservation into the Government of Bangladesh's development agenda.

- Improve conservation capacity in the Bangladesh Forest Department and its partners.
- Improve law enforcement to ensure the protection of Tigers, prey and habitat.
- Build national ability to implement education and awareness programmes, and community involvement.
- Build capacity for Tiger conservation research and monitoring.
- Encourage collaboration to support the BFD in the implementation of the BTAP.

SOUTHEAST ASIA

Indonesia

Distribution

Tigers historically existed on Bali and Java, but since 1979 have been found only on the island of Sumatra in Indonesia. Past assessments of Sumatran Tiger distribution tended to focus on several core protected areas and, occasionally, peripheral forests, thereby overlooking the more extensive forest estate (Wibisono and Pusparini 2010). A concurrent assessment of Sumatran Tiger (Panthera tigris sumatrae) occurrence across the entire island of Sumatra revealed that subpopulations of Tigers persisted in many previously overlooked landscapes (Wibisono 2021). In 2010, a study identified 38 available landscape patches for Sumatran Tiger (inclusive of TCLs), each larger than 250 km2, covering more than 140,000 km². Only 29% of these landscapes are protected, mostly as national parks. Due to logistical constraints, only 33 of these 38 landscape patches were evaluated, with evidence of Tiger occupancy confirmed in 29 landscapes (Wibisono and Pusparini 2010). In 2016, a viability analysis of the Sumatran Tiger population in the same set of landscape patches found no evidence of Sumatran Tigers in six of the 29 landscapes, leaving only 23 landscapes with Sumatran Tigers. However, the most recent study found evidence of Sumatran Tiger presence in Danau Maninjau of West Sumatra province, a landscape patch where the Sumatran Tiger was previously not detected. This updates the number of landscape patches where the Sumatran Tiger can still be found to become 24 landscape patches, ranging between 275 km² (i.e., Danau Maninjau) and 32,000 km2 (i.e., Leuser Ecosystem), with a mean patch size (±SD) of 4,309 (7,556) km2 (Wibisono and Pusparini 2010). Thus, in just six years the Sumatran Tiger might have been extirpated from five landscape patches.

Population (trend: declining)

The most recent estimate of Sumatran Tiger population was 568 adult individuals, calculated by multiplying 23 of 29 Tiger landscapes described by Wibisono and Pusparini (2010) with Tiger densities (Table 4; WCS 2015 unpublished, Pusparini *et al*. 2019). Here, we used 29 Tiger densities estimated from 16 study sites, consisting of six national parks, two wildlife reserves, one nature reserve, and seven non–protected forest landscapes (Wibisono 2021). These study sites were spread across eight of 12 Tiger conservation landscapes in Sumatra, namely Leuser – Ulu Masen (two sites), Batang Gadis (one site), Kerinci Seblat (eight sites), Rimbang Baling (one site), Tesso Nilo (one site), Kampar – Kerumutan (one site), Berbak – Sembilang (one site), and Bukit Barisan Selatan (one site) (Dinerstein *et al*. 2006). The camera trap datasets used in these density estimates were obtained between 2004 and 2018; if a site had multiple density estimates, only the most recent was used to estimate Tiger population size.

Table 5. Tiger density in each habitat type in Sumatra.

Habitat type	Density (Tigers / 100 km²)
Lowland	2.8
Hill	2.8
Sub-montane	1.1
Montane	0.59
Peat Swamp	0.3

To obtain population trends over the past 10 years, we used the same density estimates applied to 2008 and 2017 forest cover datasets. Given that the Sumatran Tiger might not use the entire forest complex, we then multiplied the population estimates with the proportion of area occupied (POA) by Tigers estimated from seven Tiger conservation landscape regions, namely Central Sumatra, Eastern Sumatra, Kerinci Seblat – Batanghari, Leuser – Ulu Masen, Northern Riau, Southern Sumatra, and Way Kambas (Wibisono 2021). Additionally, Wibisono *et al*. (2011, 2021) only covered 60% of potential Tiger habitats; thus, we also included the previously non–surveyed habitats in West Sumatra and North Sumatra provinces and used the average POA of all regions to estimate the population sizes of these two regions. Using these parameters, the island–wide Sumatran Tiger populations was estimated to be 439 (192–996) and 393 (173–883), in 2008 and 2017, respectively, suggesting a 10% decrease in Sumatran Tiger population over that 10–year period, conservatively assuming that forest cover alone affected population size.

We considered that the estimated Tiger population in this assessment presents the best attempt of estimating the Sumatran Tiger numbers. First, none of the previous estimates of Sumatran Tiger populations, including the density estimates that were used by Pusparini *et al*. (2019), investigated the effect of important covariates, i.e., habitat types and protection status. The density estimates we used in this assessment (i.e., Wibisono 2021) improved the previous Sumatran Tiger densities from across 16 sites by incorporating these two covariates into the model. Second, by taking into account the POA into the calculation of Tiger population size, we then incorporated one more source of variation into the island–wide estimate.

A viability analysis of the 23 landscapes identified as retaining Tigers in 2016, reported that only three landscapes can support viable Tiger populations (defined as a site with 40 adults embedded in a larger landscape containing 70 individuals), namely Leuser – Ulu Masen, Kerinci Seblat, and Bukit Tigapuluh (Pusparini *et al*. 2019).

Habitat Status and Threats

After more than two decades of being classified as Critically Endangered by the International Union for Conservation of Nature (IUCN), Sumatran Tiger populations continue their decline, driven by illegal poaching and retaliatory killing due to conflict with local communities. Meanwhile, rapid forest loss has left Tiger habitat fragmented. Agriculture, the main driver of deforestation, has contributed to an estimated loss of 27% of tropical forests across the island between 2000 and 2016 (Global Forest Watch 2021), and with demand for products such as palm oil, coffee, and timber only increasing, this trend will continue. While 10 national parks protect a large portion of the Sumatran Tiger population, much of the land within these protected areas is sub-optimum highland habitat; thus, up to 70% of the remaining high-quality Sumatran Tiger habitat lays outside of the protected area network. Thus, a substantial proportion of Sumatran Tigers live in isolated, unprotected marginal habitats, leading to

illegal poaching and high rates of human–Tiger conflict that often result in the death of a Tiger or its removal from the wild.

Conflict between Tigers and humans, along with illegal poaching and trafficking, remain the major threats for the Sumatran Tiger. A comprehensive study revealed that between 2001 and 2016, 130 Tigers were killed due to conflict with local inhabitants (more than 8 Tigers per year; Kartika, 2016). Another study on international Tiger trafficking between 2000 and 2018 ranked Indonesia as the third largest supplier of Tiger parts in the world after India and Thailand with an estimated 266 Tigers from Sumatra entering the trade network during that period. At the same time, Tiger seizures between 2012 and 2016 in Indonesia increased seven–fold. While this revealed that Indonesia was the most active country in Tiger seizures, it also indicated that Tiger poaching was still rampant, and thus, still the major threat to the Sumatran Tiger's existence (Wong and Krishnasamy 2019).

This information may indicate that strengthened Tiger conservation efforts by the Government of Indonesia and its conservation partners over the past decade have not been sufficient to reduce the impact of poaching, habitat loss, and human–Tiger conflicts. More recently, new threats have arisen that were not anticipated in the previous Sumatran Tiger conservation action plans. For example, the numbers of wild boar, the principal prey for the Sumatran Tiger, are declining due to an outbreak on African Swine Fever (ASF) in Sumatra. First reported in Asia in China in 2018, the disease has quickly spread, with reports of multiple deaths of wild boar from all provinces on the island of Sumatra (Exploitasia 2021). A literature survey indicated a substantial decrease in the abundance index of wild boar in several Sumatran Tiger landscapes (Wibisono, pers observation). Most recently, a study reported the occurrence of Canine Distemper Virus (CDV) in a wild Sumatran Tiger (Mulia *et al*. 2021). Studies from Russia (Gilbert *et al*. 2020) suggest that CDV is less threatening to large populations of Tigers, another reason to strive to retain large, interconnected landscapes for Tigers.

Conservation activities

Following the, the Ministry of Environment and Forestry (MoEF) and key conservation partners have implemented annual Tiger monitoring using camera traps in four major Tiger conservation landscapes, including Leuser – ulu Masen, Kerinci Seblat – Batanghari, Berbak, Sembilang, and Bukit Barisan Selatan. The monitoring datasets were used to estimate the Tiger densities reported in this assessment (Wibisono 2021). Along with the monitoring, the MoEF has also implemented anti-poaching patrols using SMART patrol monitoring systems, human – Tiger conflict mitigation, and anti wildlife trafficking network. Since 2017, the MoEF has rescued, rehabilitated, and released 14 problem Tigers back to the forest; two of them were fitted with GPS collars. In 2018, the MoEF and major partners started the second Sumatra–Wide Tiger Survey, an occupancy survey targeting 712 grid cells of 17 by 17 km each, spanning over 129,000 km² (Chandradewi *et al*. 2019). A total of 542 (78%) grid cells have been completed to date. In 2021, the MoEF initiated a multi-party forum to investigate and anticipate the impact of the African Swine Fever outbreak. In 2019, the MoEF and key partners completed a population viability analysis (PVA) for Sumatran Tiger (Pusparini *et al*. 2019). The key findings of the PVA have been used as a basis for the development of the Sumatran Tiger Strategic and Action Plan: 2019–2029. The action plan is currently being reviewed by the MoEF.

Key strategies include:

- Strengthen the capacity of Sumatran Tiger conservation through research–exploration, knowledge management, and training and education.
- Increase the effectiveness of Sumatran Tiger landscape management both in major landscapes and marginal habitats.

- Strengthen the protection of Sumatran Tigers from habitat destruction, poaching, and conflict through effective patrols and law enforcement.
- Strengthen networks and partnerships for Sumatran Tiger conservation that increase mutual benefits, supports, and added value to the community and stakeholders.
- Improve infrastructure and strengthen human – Tiger conflict mitigation to save problem Tigers and threatened populations.
- Increase permeability and connectivity between habitat clusters in fragmented habitats.

Myanmar

Distribution

The current Tiger population of Myanmar is restricted to two landscapes: the Upper Chindwin Landscape (UCL) in Kachin State and northern Sagaing Region, and in the rugged mountains of the Dawna–Tenasserim Landscape (DTL) of Kayin State, and Tanintharyi Division, along the border with Thailand. This general distribution is similar to that reported by Lynam (2003) based on central government–led countrywide survey efforts between 1999–2001, which confirmed Tigers from only 2 of 17 survey areas: the DTL and UCL.

A small number of Tigers have been detected since 2013 across a number of isolated protected and unprotected sites throughout the Dawna Tenasserim Landscape (Moo *et al*. 2017). However, extensive survey efforts across the DTL resulted in few Tiger captures, with most survey sites lacking evidence of Tiger presence. Most of these occupied sites operate under the jurisdiction of the Karen National Union's Kawthoolei Forestry Department (KFD), whose protected area system and land management regime differ from the central Myanmar Government. In Karen State, opportunistic camera trapping surveys have detected male Tiger presence throughout the Western Karen Hills in Klemuthoopli Wildlife Sanctuary, (proposed) Yomujoh Wildlife Sanctuary, and various community forests, though only a single individual has been confirmed. In the past male and female Tigers were photographed in the Dawna Range near the Thai border, including Kweekoh Wildlife Sanctuary, though since 2018 surveys have only detected a single female in the area, with no evidence of breeding.

In Tanintharyi Region, Tigers were detected in Keserdoh Wildlife Sanctuary in 2017 and Ler Mu Lah Wildlife Sanctuary in 2018 and 2019 and the southern part of Tanintharyi Nature Reserve (a single female not previously detected in Myanmar) in 2019.

Outside the DTL, recent Surveys in potential habitat in townships along the Rakhine Yoma mountain range have failed to confirm the presence of Tigers nor have surveys in Alaungdaw Katthapa National Park, Natmataung National Park or from North Zamari proposed Wildlife Sanctuary, Bago Region (MONREC 2020, Hein *et al*. 2020). Extensive recent surveys in Hponkanrazi Wildlife Sanctuary and Hkakaborazi National Park in the extreme north of the country failed to detect Tiger suggesting extirpation from this region (Lwin *et al*. 2021).

The Upper Chindwin landscape extends along the Hukaung valley. Most of the landscape is included within several protected areas, notably, Hkakaborazi National Park, and Hukaung Valley, Hponganrazi, Htamanthi, and Bumhpabum Wildlife Sanctuaries (WS). Presence of Tigers has been confirmed in Hukuang Valley WS, Htamanthi WS, and Bumhpahum WS via camera trap and/or sign surveys.

Population (trend: declining)

The current Tiger population of Myanmar is estimated as a minimum of 22 individuals. It seems likely that the overall Tiger population has declined during the assessment period with Lynam (2003)

producing a ‘best guestimate’ of Tiger numbers in Myanmar of 150 individuals which, in 2010, was revised to around 85 individuals (Goodrich *et al*. 2015). More recent camera–trapping has suggested a minimum population of 22 Tigers (MONREC 2020).

In the Upper Chindwin Landscape, there is recent direct camera–trap evidence of Tigers only from Htmanthi Wildlife Sanctuary, Sagaing Region. In 2014, five individual Tigers (one male and four females) were recorded at 18 out of 82 camera trap stations, during 7,365 trap nights in Htamanthi Wildlife Sanctuary (Naing et al. 2017, MONREC 2020). There are no recent camera–trap surveys from Hukaung Valley Wildlife Sanctuary or Hukaung Valley Wildlife Sanctuary Extension due to the inaccessibility of the area though pug–marks suggest Tigers remain extant in these protected areas. This contrasts from 2002–2004 when at least seven individual Tigers were camera–trapped from the core area of Hukaung Wildlife Sanctuary (Lynam *et al*. 2009). For southern Tanintharyi (Lenya, Lenya extension, remaining Parchan reserved forest and its vicinity) a total of eight Tigers were detected (two male, four female and two unknown) in 40 grid cells (4 x 4 km) between 2015 to 2019. Evidence of Tiger breeding was recorded in camera traps in the landscape (FFI 2018).

Threats

In 2016, a Tiger was killed that had dispersed from the Western Forest Complex in Thailand to the Dawna Range area (Wong 2016) indicating an intact transboundary corridor connecting Tiger habitats (Greenspan *et al*. 2021). Use of snares continues across much of the forested lands of Myanmar, threatening both Tigers and the prey they depend upon. Extensive logging in both Tiger landscapes, along with extensive mining operations threaten Tiger habitat and connectivity between protected areas. The extent of targeted poaching for Tigers in the DTL is unknown, though all protected areas demonstrate some illegal hunting. A Tiger was reported poisoned by local villagers in the Western Karen Hills in 2019, though photographic evidence was not produced. In Southern Tanintharyi high human pressure and habitat degradation in the landscape is impacting the Tiger populations (Aung *et al*. 2017) and two Tigers were killed in 2018 (Shew et al. 2021) with another in late 2021 as a result of apparent human–Tiger conflict (Nay Myo Shwe in. litt., 2021). Given the very small total population of Tigers in Myanmar, the documentation of at least five hunting mortalities from the DTL since 2016 highlights the perilous status of the country’s Tigers.

Conservation activities

As a result of the current political situation in Myanmar there are limited active conservation efforts focused on Tigers. Previously civil society, both international and local, have provided support to both Union and Non–Union (e.g. Karen National Union) governments for protected area establishment, ranger training, protected area management, and Tiger and prey monitoring. There remains ongoing Tiger and prey monitoring at Htmanthi Wildlife Sanctuary (WCS and NWCD).

Malaysia

Distribution

Tigers occur widely at low densities within the forests of Malaysia’s central spine with core populations in the Belum–Temengor Complex (~3,500 km²) and Taman Negara National Park (~4,300 km²) and occurrence within connected forest across the Titiwangsa and Taman Negara Ranges. An isolated population occurs in the Endau Rompin Complex (~2,400 km²) in southern Peninsular Malaysia as well as a much smaller isolated population within the Bintang Hijau Range.

Population (trend: declining)

Currently, there are no rigorous country–wide estimates of Tiger numbers available, but evidence suggests that the Tiger population in Malaysia is declining with current public estimates of less than 200 Tigers (Department of Wildlife and National Parks, in. litt. 2021). This number will be refined following the analysis of the 1st National Tiger Survey which collected data from approximately 40,000 km2 between 2016 and 2020. The final population estimate is expected to be significantly lower than 200 and will demonstrate the perilous conservation state of the Tiger in Peninsular Malaysia. We use an estimated population of 100 Tigers for Malaysia (S Table), which will need to be updated when results of the national survey are released. It is clear that the Malayan Tiger population is now facing a severe threat of extinction (Ten *et al*. 2021).

The population estimate above compares to an estimate of c. 500 wild Tigers in Peninsular Malaysia (Kawanishi and Lynam 2008) at the beginning of the assessment period. This estimate was first provided by Topani (1990) based on surveys and human–Tiger conflict reports and was similar to estimates from Kawanishi *et al*. (2003), who derived this figure based on assumptions that: (1) tropical forests had at least one Tiger per 100 km²; and (2) confirmed and expected Tiger habitats in Malaysia encompass a total of 49,300 km² (Clements *et al*. 2010).

In Royal Belum State Park, which supported one of the highest densities of Tigers in Malaysia, and the adjacent Temengor Forest Reserve the population of Tigers declined by more than 50% between 2009–2011 and 2015–2018 (WWF Malaysia, in litt. 2021). These declines were believed to have been driven by targeted poaching for the global illegal wildlife trade which was largely conducted by Indochinese poachers. Declines in Tiger numbers at other sites across Malaysia are likely to have occurred during the same period and could have been of similar magnitudes.

Conservation activities

The National Tiger Action Plan for Malaysia (2008–2020) http://www.catsg.org/fileadmin/filesharing/3.Conservation_Center/3.4._Strategies___Action_Plans/Tiger/DWNP_2008_National_Tiger_Action_Plan_Malaysia_2008–2020.pdf) identifies four primary objectives for Tiger conservation in Malaysia:

1. Secure the Central Forest Spine with strictly protected priority areas in landscapes connected with corridors.
2. Provide effective and long–term protection of Tigers and their prey.
3. Promote and practice ecologically sound land–use, compatible with Tiger conservation outside the priority areas.
4. Apply science in monitoring the efficacy of conservation actions and improving the knowledge of Tiger ecology.

The number of law enforcement personnel within protected, and non–protected, areas within Malaysia is insufficient to effectively project Tiger and Tiger prey. As such there have been recent commitments to increase the number of rangers across Tiger landscapes and establish a National Tiger Conservation Task Force to better coordinate Tiger conservation efforts. As a result of the decreasing number of Tigers within Malaysia, the government has established a National Tiger Conservation Centre at Lanchan for the ex–situ breeding and conservation of Malay Tiger. However, a focus on in–situ protection, improved law enforcement, and more sensitive land–use planning is required to prevent the extinction of Malaysia's Tigers. Site–based initiatives at Belum State Park and Endau Rompin focus on protecting key Tiger and prey habitats and monitoring poaching and other threats.

Thailand

Distribution

Breeding Tigers in Thailand are restricted to two protected area landscapes: 1) the Western Forest Complex (WEFCOM) in western Thailand along the international border with Myanmar (125–149 adults), and 2) Dong Phayayen–Khao Yai Forest Complex (DP–KY), in eastern Thailand, which shares a border with Cambodia (20–28 adults). This distribution is different from that reported by Lynam (2010) as in the last decade Tigers have expanded from the core of WEFCOM to other parts of the forest complex. In recent years Tiger individuals known from Huai Kha Kaeng Wildlife Sanctuary have moved to other parts of WEFCOM and have been recorded now in Mae Wong, Salakphra and Chaleom Rattanakosin suggesting range expansion. A male Tiger, known to have originated from Huai Kha Kaeng, was killed by a car in central Lampang Province approximately 200 km away from resident Tiger populations indicating the extent of dispersal and transient Tigers away from the core of WEFCOM. Conversely in the last three generations (since 2000) Tigers have become extirpated from several landscapes which previously supported small subpopulations e.g. Khao Yai, Phu Khieo, Khao Sok (Suttidate *et al*. 2021). Tigers have been lost from Kuiburi National Park (R. Steinmetz pers. comm), whilst a very small number (two different Tigers camera–trapped in 2020) remain in Kaeng Krachan National Park. At least one of these individuals has also been camera–trapped in adjacent areas of Myanmar. In November 2021 a Tiger was camera–trapped from Bang Lang National Park, Yala Province in the extreme south of Thailand on the border with Malaysia. This record confirmed that a (presumably) small Tiger population (shared with Belum State Park and adjacent forests in northern Malaysia) persists in the transboundary landscape.

Population (trend: currently increasing, but declined over assessment period)

The current Tiger population of Thailand is estimated at between 145 and 177 individuals, based on compilation of site-specific camera–trap monitoring studies that covered the majority of the protected areas likely to support Tigers in the WEFCOM and DPKY complexes. (Department of National Park, in litt. 2021). Between 2006–2012, Surveys in a 624–1,026 km² survey area in Huai Kha Kaeng WS using 137–200 camera traps and 21,359 trap–days effort detected 90 individual Tigers, with density estimated at 1.25–2.01 Tigers/100 km², abundances between 35–58 Tigers, survival between 79.6%–95.5% and annual recruitment varying between 0–25 Tigers (Duangchantrasiri *et al*. 2016). Although counts of individuals are conflated with increasing areas surveyed, there is ample evidence that Tiger numbers are expanding and increasing across WEFCOM (unpubl. data). Recent surveys across Dong Phayayen–Khao Yai confirm at least 16 adult Tigers, 6 cubs/juveniles and four breeding females from 1,726 detections of Tigers in 79,909 camera–trap nights for that landscape (Ash *et al*. 2020). This is the second largest subpopulation, and it has apparently expanded its range since 2000.

There is considerable potential within Thailand for establishing new Tiger populations outside of the WEFCOM core through reintroductions, translocations, and potentially natural dispersal. Opportunities for range expansion and reintroductions include the west of DPKY (including Khao Yai National Park), the Kaeng Krachan protected area complex and the protected area complex centered around Phou Khieu Wildlife Sanctuary.

Conservation Activities

Tiger conservation actions in Thailand include regional–leading efforts on protected area management and ranger training, including pioneering SMART patrolling within protected areas in both the WEFCOM and DPKY complexes. Thailand is also the regional leader in applied research into Tiger conservation and ecology led from the Khao Nang Rum Wildlife Research Station in HKK. This has led to numerous

published papers on Tiger conservation including the only studies of radio or GPS collared Tigers from mainland Southeast Asia. Outside WEFCOM recent Tiger research has also focused on Tiger abundance estimation in Dong Phayayen – Khao Yai complex and Tiger threat assessment in Thap Lan National Park.

Other Tiger conservation activities focus on prey recovery, including translocations and reintroductions (including for Sambar and Banteng) and also habitat improvements for wild ungulates (e.g. grassland and salt lick creation). There are ongoing plans for Tiger translocations into protected area complexes that have lost Tiger populations such as Phou Khieu / Nam Nao. Work on Tiger trade includes market investigations and cross border trade monitoring, and education campaigns on the risks captive Tigers pose to wild Tiger populations.

Indochina

Tigers were historically widespread throughout Cambodia, Lao PDR, and Viet Nam ('Indochina') but were extirpated from all three countries during the assessment period. The Tiger is now extirpated from mainland Southeast Asia east of the Mekong and so has been lost from the largest dry forest tracts of Southeast Asia. Across Indochina, the last Tigers were targeted for poaching whilst prey depletion was also likely to have reduced survivorship and reproduction (Lynam 2010). The last documented Tigers in Indochina occurred in Nam Et–Phou Louey National Park in northeast Lao PDR, and whilst earlier declines were driven by targeted hunting, the loss of this final remnant population is likely to have due to an exponential increase in snaring (Rasphone *et al*. 2019) following human migration and settlement into the protected area. The loss of the Tiger from Indochina has been mirrored by a dramatic loss in Leopard Panthera pardus populations in the region (Rostro–García *et al*. 2016).

Cambodia

At the start of the assessment period, the Tiger was still fairly extensively distributed in remote forests, particularly along the country's borders with Thailand, Lao PDR and Viet Nam. Whilst a 1998 population estimate of over 500 Tigers within five forest blocks (Nowell *et al*. 1999) was likely a significant overestimate; the Tiger was still relatively widespread in Cambodia at the time. Interviews with known hunters estimated 85 Tigers poached nationwide in 1998 and 50 in 1999 from three landscapes (the Cardamom Rainforest, Eastern Plains, and Northern Plains; Sun 2000). These numbers suggest a rapid decline in the Tiger population at the beginning of the 21st century due to targeted poaching for domestic and international trade. For example, a single poacher, arrested in August 2005 in the Cardamom Rainforest, claimed to have poached 19 Tigers (WildAid 2005). Between 2000 and 2005 an additional 26 Tiger poaching incidents were clearly documented: the last of these was from the Cardamom Rainforest in May 2005 (Chheang *et al*. 2006). A total of 77 confirmed (camera–trap photograph or measured footprint) Tiger records from four landscapes were obtained by conservation NGOs between 1996 and 2007 with the last record being a female camera–trapped in Srepok Wildlife Sanctuary in the Eastern Plains Landscape, Mondulkiri in November 2007 (Gray *et al*. 2012). There were subsequent unconfirmed claims based on footprints from other protected areas in the Eastern Plains Landscape until at least 2010 (Lynam 2010). Extensive camera–trapping across the vast majority of forested landscapes in Cambodia, and dog scat detection surveys in key protected areas (including Srepok and Keo Seima Wildlife Sanctuaries), have not subsequently detected any Tigers (e.g. O'Kelly *et al*. 2012, Gray *et al*. 2017a, Loveridge *et al*. 2018). Applying a non–parametric extinction date estimator (Clements *et al*. 2013) to the confirmed Tiger records estimates extirpation in Cambodia by July 2008 with a 95% upper confidence interval of August 2015 (TNE Gray, pers. comm. 2021). Occasional, unconfirmed, reports of Tiger footprints in north-west Cambodia may represent dispersers

or transient individuals from the Dong Phayayen–Khao Yai Forest Complex (DPKY–FC) population in Thailand where Tigers range as close as 30 km from the Cambodian border (Ash *et al*. 2021).

Viet Nam

At the beginning of the assessment period, Viet Nam is likely to have supported a small Tiger population (fewer than 20) in forests along the country's borders with Cambodia and Lao PDR. The last camera–trapped Tiger from Viet Nam was in Pu Mat National Park, Nghe An Province, in 1999, whilst a measured footprint was recorded in February 2002 from Song Thanh National Park, in Quang Nam Province (V Nguyen Dao Ngoc, pers. comm. 2021). There have been no subsequent confirmed records of wild Tigers from Viet Nam. A 2012 estimate of less than 30 Tigers in Viet Nam, derived from questionnaires conducted by the Institute of Ecology and Biology Resources, is likely to be highly optimistic, and the Tiger is believed to be extinct in Viet Nam. The extensive use of cable snares throughout forested areas of Viet Nam unquestionably accelerated the decline of the country's Tiger population and has caused significant population declines in all cat and ungulate species across the country (Wilcox *et al*. 2014, Tilker *et al*. 2019, Belecky and Gray 2020).

Lao PDR

At the beginning of the assessment period, Lao PDR may have had the largest Tiger population in Indochina, and Walston *et al*. (2010) regarded Nam Et–Phou Louey (NEPL) National Park as an important source site for Tiger conservation. Between 2006 and 2009 the only confirmed Tiger records from Lao PDR were from NEPL despite the suggestion, in the 2010 national Tiger action plan, of 'likely presence' in 13 other Protected Areas (Lynam 2010). The last record of a Tiger from southern Lao PDR appears to be from Xe Sap National Protected Area in May 1999 (Steinmetz et al. 1999). The last record of Tiger anywhere in Lao PDR outside of NEPL was probably in Nam Ha NPA near the border with China (WCS Laos). There have been subsequent reports of the Tiger from Nam Pouy NPA, a large and remote protected area west of the Mekong and bordering Thailand, but there are no confirmed records from the site (K. Khounboline, pers. comm. 2020).

Within NEPL, Johnson *et al*. (2006) estimated the Tiger population to lie between 7 and 23 individuals in 2003/04, whilst a minimum of nine individuals was identified based on DNA analysis of scats in 2009 (Vongkhamheng 2011). The population subsequently declined rapidly, with only two individuals detected by camera–traps in 2013 (Rasphone *et al*. 2019), comprising the last confirmed Tiger records from the landscape, the country, and Indochina. The decline in Tigers in NEPL was associated with targeted big cat snaring following road building and human migration into the protected area, where there has subsequently been a decline in smaller cat species as well (Rasphone *et al*. 2019, Rasphone *et al*. 2021).

Conservation Activities

Wild Tigers no longer occur in Cambodia, Lao PDR, Viet Nam, or southern China. As a result, site-based Tiger conservation efforts are focused on restoring prey populations and securing conditions for potential Tiger reintroduction with a primary focus on Cambodia (Gray et al. 2017b). This includes improving protected area management and law enforcement to reduce hunting and habitat loss. Within Cambodia, two landscapes: the Cardamom Rainforest in the south-west and the Eastern Plains Landscape in Mondulkiri, have been identified for future potential Tiger reintroduction if protected area management effectiveness can improve and the declining trend in forest loss stabilized. In Lao PDR and Viet Nam Tiger conservation efforts largely now focus on addressing trade in Tiger parts and captive Tiger populations – particularly ensuring that they comply with CITES resolutions. Site–based

conservation initiatives at Nam Et–Phou Louey and southern Annamites in Lao PDR include support for law enforcement and wildlife protection. There is also a concerted effort to reduce demand for the consumption of Tiger parts through targeted evidence–based behavior change. In Lao PDR and southern China transboundary conservation initiatives have focused around habitat management.

NORTHEAST ASIA

Russia

Distribution

Breeding Tigers are distributed across the Sikhote–Alin Mountains of Primorye and Khabarovsk Provinces, and the Changaishan Mountains of Southwest Primorye (and neighboring China) (Miquelle *et al*. 2010, Wang *et al*. 2018). A single continuous population occurs across the length of the Sikhote–Alin Mountains (about 1,000 km north to south), as demonstrated by no genetic differentiation across this landscape (Henry *et al*. 2009, Sorokin *et al*. 2015). Tigers in Southwest Primorye are, however, genetically distinguishable from the Sikhote–Alin population (Henry *et al*. 2009. Sorokin *et al*. 2015), even though there is evidence of movement between these two subpopulations. Tiger range expanded to the west via a relocation program starting in 2013 that released rehabilitated orphaned cubs into the Pri–Amur region (the Jewish Autonomous Region and Amur Oblast) of Russia (Rozhnov *et al*. 2021). Survival rates of these relocated Tigers have been high and at least three females have produced litters and likely bred with both reintroduced males and males that dispersed from the Sikhote–Alin population. This new subpopulation appears to be expanding.

Movement of Tigers across the international border into China occurs primarily in three regions:

1) in the Changbaishan Mountains of Southwest Primorye Russia, and Jilin Province of China, where Tigers most often traverse between the Land of the Leopard National Park (Russia) and the Northeast Tiger Leopard National Park (China);
2) along the border between the Bikin River north to BolsheKhekhtsirski Zapovednik (in Russia) and the Wandashan Mountains (of China); and
3) from the Pri–Amur region of Russia where relocated Tigers have crossed the Amur River into China at least three times (Qi *et al*. 2021).

Population (trend: stable)

Methods used to estimate Population Size. We gathered all estimates of Tiger density between 2015 and 2020 that used camera traps and which applied statistical spatial and non–spatial models to derive density estimates (converting non–spatial estimates based on an equation derived by A. Harihar across all Tiger range). When more than a single estimate was derived for a given site for a given year, we selected the estimate that was based on the largest minimum convex polygon derived from the array of cameras. This resulted in a sample size of 25 density estimates. We derived a mean estimate for each site (n=12) where there was more than a single estimate between 2015 and 2020. We then derived a median, and 25 and 75% quartile density estimate for protected areas (n=5) and unprotected areas (n=5), discarding estimates that included both types (n=2). Hebblewhite *et al*. (2010) estimated that Tigers were distributed across 155,000 km² of suitable habitat for Tigers in the Sikhote–Alin/Southwest Primorye region of the Russian Far East. We believe that estimate has not changed substantially since it was derived, except we added an additional 8,000 km² of suitable habitat in the Pri–Amur region where a population of Tigers has been established by relocation (see above). Protected areas represent approximately 20% of the suitable habitat for Tigers in Russia, so we applied median density

estimates for protected (32,600 km²) and unprotected lands (130,400 km²) and summed them to derive an estimate of Tiger abundance in Russia. Confidence bounds were derived using the 25% and 75% quartile density estimates.

Population Size and Trends

Using the above approach, the current adult/subadult Tiger population of Russia is estimated at 386, ranging between 265 and 486. If we assume that 30% of that adult/subadult population is not breeding, we estimate a population of 270 breeding adults.

Over the past three generations of Tigers (since 2000) three full range surveys have been conducted that detail distribution of Tiger tracks in winter (Fig.2). Direct interpretation of the results might suggest that there has been a slight increase in Tiger numbers. However, results are based on expert assessments without statistically robust analyses, making interpretation of results extremely difficult. At best, these results suggest there has likely been no significant change in the distribution of Tigers over that time.

Habitat Status

Although protected lands that harbor Tigers have increased (including the creation of the 11,600 km² Bikin National Park in 2016) protected areas still represent only 20% of the suitable habitat for Tigers in Russia. Most Tiger habitat consists of "GosLesFund" lands (managed Forest Service lands) or regional/local forested areas that are managed for multiple uses (Miquelle *et al*. 1999). Collectively these are multiple–use lands that are subjected to continued legal and illegal timber harvest, mining, hunting, and other resource extractive activities.

Threats

Poaching is still considered the primary cause of mortality for Amur Tigers in Russia (Goodrich *et al*. 2010, Robinson *et al*. 2015, Skidmore 2021), and is likely responsible for the lack of population growth over the past 20 years. Increasing densities of logging roads provide greater access both for poaching and illegal timber harvest (Kerley *et al*. 2002, Slaght *et al*. 2017, Skidmore 2021), and poaching of prey likely dampens potential Tiger densities, especially outside protected areas. Improved access via logging roads is probably a greater threat than the logging itself, except when logging targets tree species that provide key mast crops (e.g. Mongolian oak, Korean pine) that are vital to overwinter survival of prey species (e.g. wild boar, red deer). The arrival of African swine fever in the Russian Far East in 2019 had a major impact on the wild boar population (Zakharova *et al*. 2021), which is the most preferred prey species of the Amur Tiger (Miquelle *et al*. 2010, Kerley *et al*. 2015).

Conservation activities

The Russian Federal Government's Tiger Conservation Strategy was revised in 2019, including a "roadmap" of necessary actions and responsible agencies/organizations. Continued expansion of the protected areas network within Tiger range, including the creation of Bikin National Park in 2016 (the largest protected area in Russia with Tigers at 11,600 km²) was of special significance, given its high Tiger densities. Increased support to the wildlife departments responsible for enforcement outside of protected areas has improved conditions in many portions of the Tiger's range. Strong law enforcement in Land of the Leopard National Park, created in 2012 has led to a doubling of Tiger numbers, providing a model for how to recover Tigers in northeast Asia.

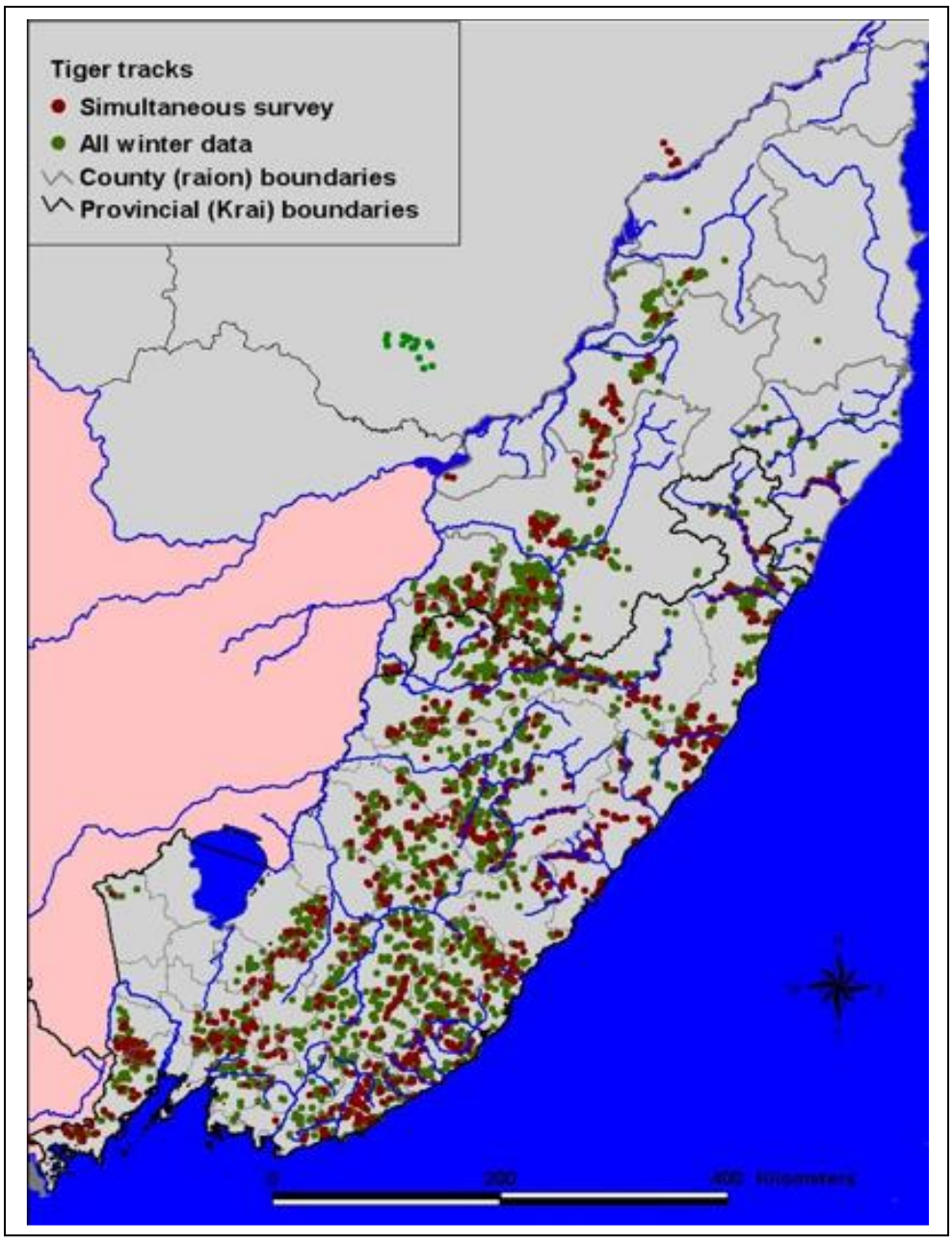

Figure 2. Distribution of Tiger tracks reported from full range winter surveys in 2005.

China

Distribution

Tigers were historically distributed widely in China, including representation of five separate subspecies (*sensu* Luo *et al*. 2004). What was considered the last population of Caspian Tigers in China, found along the banks of the Luobupo Lak and Talimu River of Xingjiang disappeared in the 1920s (Gao 1994). Currently, there is no evidence of Tigers in the range of what was considered the “South China” Tiger subspecies (originally ranging from Fujian and Zhejiang Provinces in the east to Sichuan in the west, from the Xijian River Basin in the south to Shanxi, Gansu and Shaanxi Provinces to the north)

since 2001 (Tilson *et al*. 2004) suggesting that the last remaining individuals of this population are all in captivity. Within the former range of the Indo–Chinese subspecies, a single female Tigress was photographed in Xishuangbanna National Nature Reserve in Yunnan Province in 2004 (Feng *et al*. 2008), and another three individuals (one male, two females) were reported in Shangyong Nature Reserve of Yunnan Province during the period from 2004 to 2009 (Feng et al. 2013). Reports of poaching suggested these animals were lost by 2009 (Feng, pers. comm.). Camera trap surveys in the former range of the Bengal Tiger in Medog County along the Yarlung Zangbo River photographed three non–resident males but no evidence of resident or breeding individuals (Wang *et al*. 2019).

The last potentially viable population of wild Tigers in China appears to be along the northern border with Russia. This population currently is centered in the Laoyeling region, especially Hunchun County in Jilin Province, and the southeast portion of neighboring Heilongjiang Province, adjacent to the border with Russia (Wang *et al*. 2018). Dispersal of Tigers from Southwest Primorye Russia appears to have been key to recovery of this population, and while many individuals still use both sides of the border (Matiukhina, pers. comm.), there are breeding females living entirely on the Chinese side.

Individuals have also been reported sporadically in the Eastern Wandashan Mountains over the past twenty years, with evidence that Tigers have crossed the Ussurii River from Russia into this region. However, there does not appear to be a resident breeding population there (Wang *et al*. 2015, Qi *et al*. 2021). Similarly, a few records exist of Tigers in the Zhangguangailing Mountains west and north of the Laoyeling (Qi *et al*. 2021). Finally, there are records of Tigers released into the Pri–Amur region of Russia crossing the Amur River and spending a month or more in the Lesser Khingan Mountains in northern Heilongjiang, but there appears to be no breeding population here since the 1970s.

Population (trend: increasing)

Multiple surveys suggest a growing population in the Laoyeling region (Fig. 3). Surveys in 1998 and 1999 suggested only a few dispersing males were present (Jiang 2005, Yu 2005). Ten to eleven individuals were photographed in 2013–2014 (Xiao 2015) but some portion of those animals spent more time in Russia than China. Up to 60 Tigers (adults, subadults, and cubs) were camera–trapped in the region of the Northeast Tiger Leopard National Park in 2020 (Feng pers. comm.), but it is estimated that only around 14–16 adults are primarily living on the Chinese side of the Sino–Russian border in this region. A few solitary males are also reported in the Wandashan and Zhangguangailing Mountains (Qi *et al*. 2021), so the total number of Tigers permanently living within northeastern China is probably less than twenty (L. Feng, K. Weiyao, pers. comm.). However, there appear to be opportunities for expansion and growth of this population (Hebblewhite *et al*. 2012, Wang *et al*. 2016, Qi *et al*. 2021).

Habitat Status and Threats

The halting of logging across most of northeast China since 2000 as part of the Natural Forest Protection Project has resulted in recovery of forest stands, reduced human population impacts on potential Tiger habitat, and perhaps allowed some recovery of ungulate populations. But low prey densities still appear to be a primary challenge to recovery of Tigers in Northeast China (Zhang 2013, Qi *et al*. 2021). Cattle grazing in Tiger habitat also reduce natural prey abundance and increases levels of conflict (Soh *et al*. 2014, Wang *et al*. 2018). Although long–distance dispersal of Tigers has been recorded in China (Wang *et al*. 2015, Qi *et al*. 2021) connectivity between forested mountain regions both within China and across the border with Russia will be key to ensure an integrated meta–population of Tigers in northeast Asia.

Conservation activities

In 2001 China created the Hunchun Tiger Leopard Reserve, a 1,087 km² sliver of habitat along the border with Russia, providing a stepping stone entrance for Tigers from Southwest Primorye, Russia. In 2016 China created the 14,600 km² Northeast Tiger Leopard National Park, which encompassed Hunchun and several other protected areas. This park represents the largest protected area for Tigers in Asia, and is currently the centerpiece of Tiger conservation in China.

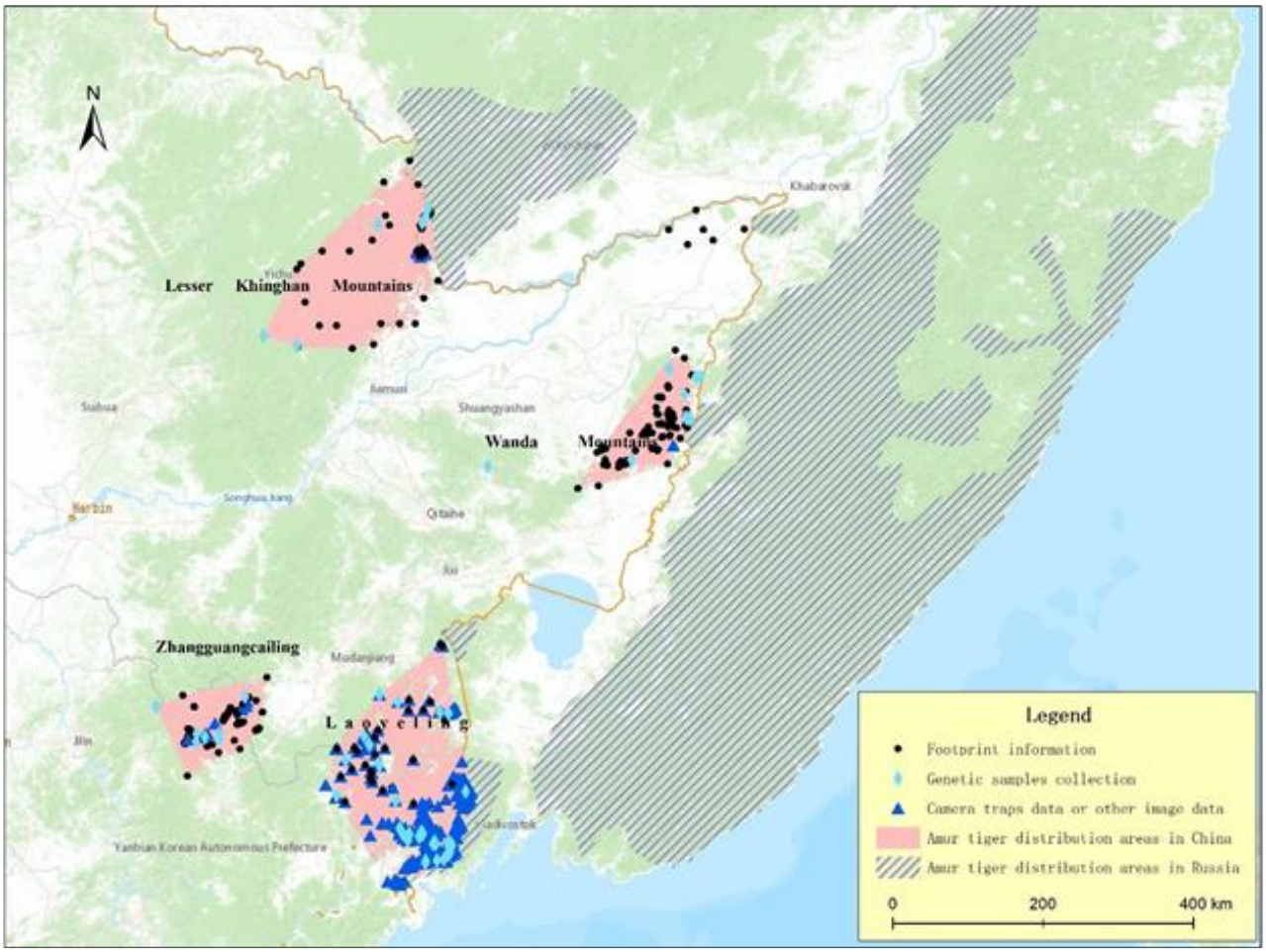

Figure 3. Distribution of Tigers in Northeast China (provided by Guangshun Jiang).

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